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A STUDY OF THE OPTICAL PROPERTIES OF SOME UNSATURATED KETONES.

BY FREDERICK H. GETMAN.

In a previous communication[1] we undertook the determination of some of the physical properties of unsaturated ketones and the investigation of the relation of these properties to their chemical behavior. In that paper the values of the surface tensions and densities of the following substances are recorded: mesityl oxide, benzalacetone, benzalmethylethyl ketone and benzalpinacolin.

It was shown by means of the well-known Eötvös-Ramsay relation and the empirical formula of Longinescu that these substances are nonassociated.

In the present paper the refractive indices, the dispersions and the absorption spectra of these compounds have been determined.

PART I.

Refraction and Dispersion.

The refractive indices were measured by means of the new form of Pulfrich refractometer,[2] using the *D* line of sodium and the *C*, *F*, and *G* lines of hydrogen. The temperature was controlled by means of the heating apparatus of Van Aubel, as made by Zeiss, and rarely varied more than one-tenth of a degree during the measurement. The mesityl oxide used

[1] Getman: THIS JOURNAL, **44**, 145 (1910).
[2] Pulfrich: Z. physik. Chem., **18**, 294 (1895).

was obtained from Kahlbaum while the other substances were prepared in this laboratory and were subjected to repeated crystallization from low-boiling ligroin.

Owing to the tendency of these unsaturated compounds to become yellow on exposure to light and air, special precautions were taken to keep them in tightly-stoppered bottles in a dark place and to use them as soon as possible after preparation. That the refractive index changes on prolonged exposure was shown by the following experiment with mesityl oxide. The refractive index at 23°.5 of freshly distilled and nearly colorless mesityl oxide was found to be 1.44411, whereas the refractive index of the same specimen at the same temperature after seven weeks' exposure to diffuse light in a covered beaker was 1.44481. The mesityl oxide had acquired in this time a decided yellow color. The values of the refractive indices of the four compounds studied are given in the following tables, n_D, n_C, n_F, and n_G denoting the indices for the *D*, *C*, *F* and *G* lines.

Table I.—Mesityl Oxide, $(CH_3)_2C : CH.CO.CH_3$.

Temp.	n_D.	n_C.	n_F.	n_G.
13°	1.44840	1.44478	1.45831	1.46699
28°	1.44324	1.43768	1.45065	1.45970
29°	.....	1.43716	1.45035	1.45940
32°	1.43921	1.43599	1.44912	1.45794
38°	1.43658	1.43291	1.44594	1.45464
41°	1.43494	1.42951	1.44350	1.45314

Table II.—Benzalacetone, $C_6H_5CH : CH.CO.CH_3$.

Temp.	n_D.	n_C.	n_F.
33°.5	1.58929	1.58015	.....
36°.0	1.58870	1.57916	1.60356
39°.9	1.58674	1.57724	1.61266
44°.9	1.58411	1.57504	1.61023
47°.0	1.58314	1.57411	1.60902

Table III.—Benzalmethylethyl Ketone, $C_6H_5CH : CH.CO.C_2H_5$.

Temp.	n_D.	n_C.	n_F.
36°.0	1.57485	1.56621	.....
40°.0	1.57263	1.56450	1.59718
42°.1	1.57263	1.56950	1.59275
49°.1	1.56971	1.56072	1.59266
52°.0	1.56882	1.56025	1.60279

Table IV.— Benzalpinacolin, $C_6H_5CH : CH.CO.C(CH_3)_3$.

Temp.	n_D.	n_C.	n_F.
35°.2	1.55255	1.54469	1.57393
37°.1	1.55223	1.54396	1.57294
40°.0	1.55015	1.54270	1.57125
47°.5	1.54710	1.53952	1.56795
51°.9	1.54537	1.53771	1.56598

Benzalacetone, benzalmethylethyl ketone and benzalpinacolin show absorption in the violet so that it was impossible to secure trustworthy readings for the *G* line. It is to be noted that with these substances, which are solids at ordinary temperatures, several readings were taken on the supercooled liquids, but when the refractive indices are plotted against the temperatures no discontinuity is observed at the melting point. The melting points of the three substances are as follows:

	Melting point.
Benzalacetone	40°.2
Benzalmethylethyl ketone	37°.5
Benzalpinacolin	39°.5

Each index recorded in the tables is the mean of several observations and the corresponding temperature is the average of the initial and final temperatures.

The molecular refractions have been calculated by means of the Gladstone and Dale and the Lorentz-Lorenz formulas. In the subjoined tables *R* denotes the specific refraction obtained from the formula

$$R=\frac{n-1}{d},$$

while r denotes the specific refraction calculated from the formula

$$r=\frac{1}{d}\cdot\frac{n^2-1}{n^2+2}.$$

The molecular weight is denoted by *M* while *d* denotes the density. The density was determined by means of a weight dilatometer, as previously described.

Table V.—Mesityl Oxide, $(CH_3)_2C:CH.CO.CH_3$.

Temp.	*d.*	MR_D.	Mr_D.	MR_C.	Mr_C.	MR_F.	Mr_F.	MR_G.	Mr_G.
13°	0.8672	50.67	30.21	50.25	30.28	51.79	30.84	52.76	31.37
28°	0.8525	50.95	30.46	50.31	30.16	51.70	30.94	52.84	31.49
29°	0.8519	.....	.....	50.28	30.14	51.81	30.91	52.84	31.44
32°	0.8500	50.64	30.33	50.26	30.14	51.78	30.93	52.80	31.47
38°	0.8430	50.75	30.45	50.32	30.18	51.83	31.01	52.85	31.52
41°	0.8405	50.72	30.41	50.08	30.11	51.71	30.96	52.83	31.53
	Mean,	50.77	30.37	50.25	30.17	51.77	30.77	52.82	31.47

Table VI.—Benzalacetone, $C_6H_5CH : CH.CO.CH_3$.

Temp.	*d.*	MR_D.	Mr_D.	MR_C.	Mr_C.	MR_F.	Mr_F.
33°.5	1.0142	84.83	48.53	83.51	47.96	...	...
36°.0	1.0124	84.88	48.63	83.53	47.98	87.04	49.64
39°.9	1.0095	84.86	48.62	83.48	47.90	88.61	50.30
44°.9	1.0060	84.77	48.57	83.46	47.96	88.55	50.34
47°.0	1.0043	84.77	48.72	83.46	47.98	88.53	50.43
	Mean,	84.82	48.61	83.49	47.96	88.56	50.18

Table VII.—Benzalmethylethyl Ketone, $C_6H_5CH : CH.CO.C_2H_5$.

Temp.	*d.*	MR_D.	Mr_D.	MR_C.	Mr_C.	MR_F.	Mr_F.
36°.0	0.9973	92.22	53.03	90.83	52.30	...	...
40°.0	0.9943	92.14	52.99	90.83	52.41	96.10	54.84
42°.1	0.9925	92.30	53.09	91.79	52.90	95.65	54.62
49°.1	0.9875	92.30	53.06	90.85	52.44	96.02	53.64
52°.0	0.9850	92.38	53.21	91.00	52.50	97.93	55.77
	Mean,	92.27	53.08	91.06	52.51	96.43	54.72

Table VIII.—Benzalpinacolin, $C_6H_5.CH : CH.CO.C(CH_3)_3$.

Temp.	*d.*	MR_D.	Mr_D.	MR_C.	Mr_C.	MR_F.	Mr_F.
35°.2	0.9584	108.34	62.75	106.84	61.97	112.57	64.71
37°.1	0.9570	108.48	62.73	106.86	62.00	112.56	64.73
40°.0	0.9548	108.33	62.69	106.86	62.20	112.48	64.71
47°.5	0.9490	108.37	62.82	106.88	62.13	112.52	64.79
51°.9	0.9455	108.42	62.85	106.92	62.16	112.54	64.86
	Mean,	108.39	62.77	106.87	62.09	112.53	64.76

The average molecular refractions calculated by means of the two formulas are compared with the molecular refractions computed from the refractivities of the elements as de-

termined by Brühl and Conrady.[1] In these calculations the following values have been employed:

Table IX.

	Gladstone and Dale formula.		Lorentz–Lorenz formula.	
	R_C.	R_D.	r_C.	r_D.
Carbon, singly linked	5.00	4.71	2.365	2.592
Hydrogen	1.30	1.47	1.103	1.051
Oxygen, ketonic	3.40	3.33	2.328	2.287
Ethylene linkage	2.40	2.64	1.836	1.707

The agreement between the two sets of values is fairly close for mesityl oxide (Table X), but the remaining compounds all show marked optical anomaly. Brühl[2] has pointed out that optical anomaly is to be ascribed to the relative positions of unsaturated groups within the molecule. Where there is but one unsaturated group, as in mesityl oxide, the calculated and observed values of molecular refraction are in close agreement, but when the benzene nucleus is introduced into the molecule, as in benzalacetone, benzalmethylethyl ketone and benzalpinacolin, the molecular refractive power

Table X.

	Mesityl oxide.	Benzal-acetone.	Benzalmethyl-ethyl ketone.	Benzal-pinacolin.
MR_D obs.	50.77	84.82	92.27	108.39
MR_D calc.	48.93	75.69	83.34	98.64
Δ	1.84	9.13	8.93	9.75
Mr_D obs.	30.37	48.61	53.08	62.77
Mr_D calc.	29.51	44.64	49.24	58.44
Δ	0.86	3.97	3.84	4.33
MR_C obs.	50.25	83.49	91.06	106.87
MR_C calc.	48.80	76.00	83.60	98.80
Δ	1.45	7.49	7.46	8.07
Mr_C obs.	30.17	47.96	52.51	62.09
Mr_C calc.	29.38	44.35	48.92	58.07
Δ	0.79	3.61	3.59	4.02
Mr_F obs.	30.77	50.18	54.72	64.76
Mr_F calc.	30.09	45.28	49.96	59.33
Δ	0.68	4.90	4.76	5.43

[1] Brühl: Z. physik. Chem., **7**, 191 (1891). Conrady: *Ibid.*, **8**, 210 (1889).
[2] Brühl: Ber. d. chem. Ges., **40**, 878, 1153 (1907); **41**, 3712 (1908).

becomes abnormal. An inspection of the results shows that in every case the molecular refraction is raised by the introduction of the second unsaturated group, the compounds exhibiting what has been termed "optical exaltation."[1] This abnormality in physical behavior is in perfect harmony with the chemical conduct of these compounds.

In 1886 Gladstone[2] suggested that the specific dispersive power of a substance might be represented by the expression $(n_H - n_A)/d$ and the molecular dispersion by $(n_H - n_A)M/d$, where M denotes the molecular weight and d the density. By comparing the molecular dispersions of a number of organic compounds he found that approximately constant values may be assigned to the dispersive power of hydrogen, carbon, oxygen and the halogens, thus proving dispersivity to be an additive property. Brühl[3] derived more exact values for the atomic dispersions and pointed out more definitely the relation between dispersive power and constitution. He employed the Lorentz-Lorenz relation for refractive power and calculated specific dispersions by means of the formula

$$\frac{n_x^2 - 1}{n_x^2 + 2} \cdot \frac{1}{d} - \frac{n_y^2 - 1}{n_y^2 + 2} \cdot \frac{1}{d}$$

In calculating molecular dispersion (Table XIII) the following values of Brühl were employed:

Table XI.

	Atomic dispersion, $r_F - r_C$.
Carbon	0.039
Hydrogen	0.036
Ketonic oxygen	0.086
Ethylene linkage	0.230

The molecular dispersions for the C, D, F and G lines are given in Table XII and the observed and calculated values for the F and C lines are recorded in Table XIII. The differences between the observed and calculated molecular dispersions are in every case greater than the differences obtained by Brühl for saturated compounds.

[1] Nasini: Gazz. chim. ital., **37**, II, 55 (1907).
[2] Gladstone: J. Chem. Soc., **50**, 609 (1886). P. Roy Soc., **42**, 401 (1887).
[3] Brühl: Z. physik. Chem., **7**, 140 (1891).

That there should be marked discrepancies between the two sets of values is not surprising, since it has been pointed out by Brühl that dispersive power is even more susceptible to differences in constitution than is refractivity.

Table XII.

	Mesityl oxide.	Benzal-acetone.	Benzalmethyl-ethyl ketone.	Benzal-pinacolin.
$MR_D - MR_C$	0.52	1.23	1.21	1.52
$Mr_D - Mr_C$	0.20	0.65	0.57	0.68
$MR_F - MR_C$	1.52	5.07	5.37	5.66
$Mr_F - Mr_C$	0.60	2.22	2.21	2.67
$MR_G - MR_C$	2.57	....	....	....
$Mr_G - Mr_C$	1.30	....	....	....

Table XIII.

	Mesityl oxide.	Benzal-acetone.	Benzalmethyl-ethyl ketone.	Benzal-pinacolin.
$Mr_F - Mr_C$ calc.	0.910	1.76	1.87	2.03
$Mr_F - Mr_C$ obs.	0.60	2.22	2.21	2.67
Δ	+0.31	—0.46	—0.34	—0.64

PART II.

Absorption Spectra.

The ultraviolet absorption spectra of benzalmethylethyl ketone and benzalpinacolin were obtained by means of a Fuess spectrograph fitted with a quartz prism and quartz lenses. The prism was set at the position of minimum deviation and the light from a rotating iron arc was focused upon the slit of the instrument by means of a quartz lens.

The ketones were dissolved in ethyl alcohol, the original solution being 0.0001 N. The solutions were contained in a Baly absorption tube[1] and placed before the slit of the spectrograph, the axis of the tube being coincident with the optical axis of the collimator.

After an exposure of fifteen seconds the length of the column of liquid was shortened, this being equivalent to diluting the solution, and a new exposure was made on a fresh portion of the plate.

The plates were measured by means of a comparator and the

[1] Baly: Spectroscopy, p. 414.

results plotted according to the method of Baly and Desch.[1] The curves so obtained are shown in Fig. I, the dotted curve being

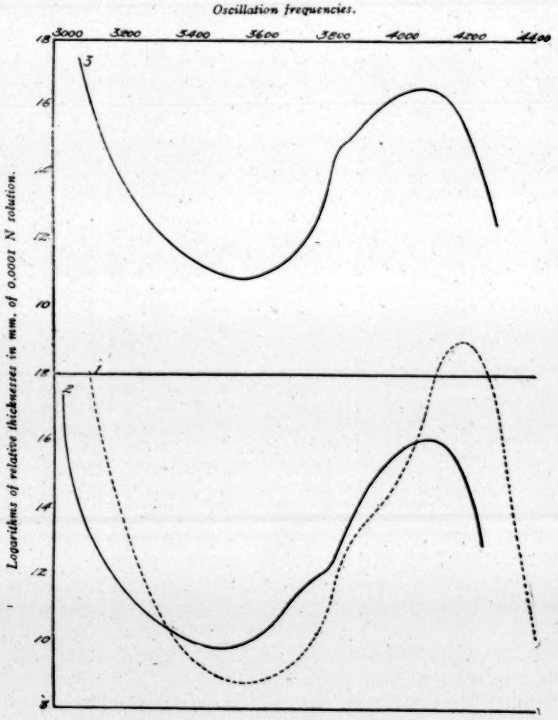


Fig. I.—1. Benzalacetone. 2. Benzalmethylethyl ketone. 3. Benzalpinacolin.

taken from the work of Baly and Schaefer.[2] The curves have the same general form, the heads of the bands being

[1] Baly and Desch: J. Chem. Soc., **85**, 1039 (1904).
[2] Baly and Schaefer: *Ibid.*, **93**, 1813 (1908).

located in the vicinity of frequency 3500 and the persistence of the bands being nearly identical. Each curve is characterized by a slight sinuosity on the ascending portion. The similarity of the absorption curves is in agreement with the similarity of chemical behavior.

The preceding data on the ultraviolet absorption spectra of benzalmethylethyl ketone and benzalpinacolin were obtained by Miss Helen Lamberton, a former graduate student of this institution, and I desire to record my appreciation of her kindness in placing them at my disposal.

BRYN MAWR COLLEGE,
BRYN MAWR, PA.,
March, 1911.

ELECTRICAL INDUCTION IN CHEMICAL REACTIONS.

BY L. G. WINSTON.

The object of this paper is to call attention to certain neglected aspects of chemical reaction, particularly the rôle which electrostatic induction may play. I mean, of course, by electrostatic induction the electrical attractions and repulsions of unlike and like charges, respectively. From the time of Berzelius, electrochemical theories have been advanced to explain chemical reaction, but in none of these is electrostatic induction properly taken into account.

This is difficult to explain, since the conditions demanded by the theories are just those which would give rise to inductive action. There are present ions carrying electrical charges, neutral undissociated molecules, and a nonconducting medium.

Sir J. J. Thomson's conception of the atom will be adopted in this discussion. According to him the atom consists of a sphere of positive electricity, through which are distributed the negative electrons. The whole is in a state of dynamical equilibrium.

An electron is either a small particle of matter carrying a unit negative charge of electricity, or simply a unit negative charge of electricity. We know practically nothing about the nature of positive electricity.

An atom that has lost an electron is electropositive.

An atom that has gained an electron is electronegative.

Chemical reactions are fundamentally connected with losses or gains in electrons.

With these ideas in mind, let us turn first to the consideration of one of the most characteristic reactions of carbon—the power to form homologous compounds.

Inorganic compounds are, in general, strongly dissociated. Here, chemical action is almost entirely ionic and induction plays little or no part.

Organic compounds, on the other hand, are weakly dissociated. Therefore, in solution we have only a few ions and a large number of undissociated molecules present.

Homology is effected by the substitution of a radical for a hydrogen atom. Objection has been made to some electrochemical theories in that in the formation of compounds such as ethane, either two similar groups (CH_3) having like charges must unite, or of necessity one methyl group must act positively and the other negatively. By means of the conception of the rôle played by induction this objection is, at least to some extent, removed.

In ordinary electrostatic induction in a conductor the following takes place. When a body charged, say positively, is brought near to a neutral body from which it is separated by a nonconducting medium, the electricities in the neutral body become separated. The negative is drawn nearest to the positive inducing body, while the positive is repelled. If, while the inducing body is still near, the repelled positive charge is removed, the once neutral body is left negatively charged.

Similarly, when positive methyl ions are brought into the presence of methane (or one of its substitution products in which one hydrogen atom has been replaced), ethane would be formed. The positive methyl group, approaching the neutral molecule of methane but separated from it by a nonconducting medium, would cause the electricities in the neutral molecule to separate.

We must, however, not think of the electricity as separating sharply into positive and negative—the positive of all the atoms accumulating in one-half of the molecule and the nega-

tive in the other. With Thomson's conception of the atom still in mind, we must think of the individual atoms within the molecule. The electrons within the atom, under the influence of the inducing body, still retain their same relative positions.

The inducing body merely draws nearer to itself the center of gravity of the negative electrons of each atom, repelling likewise the center of gravity of the positively charged part of each.

The inducing body, in drawing nearer to itself the electrons, draws one electron out of a hydrogen atom. Thus, one part of the molecule CH_4 gains an electron, becoming electronegative, and the hydrogen, losing an electron, becomes electropositive; the hydrogen, being positive, is repelled by the positive inducing body. The electrons, previously in a state of equilibrium, are now no longer in equilibrium. The repelled hydrogen ion will escape, if possible, and leave the molecule of methane (minus a hydrogen atom) charged negatively. The positive methyl group (the inducing body), being near, is attracted and finally drawn into the molecule.

In ordinary electrostatic induction, contact with a neutral body is necessary to remove the repelled charge, but here it is not necessary, since rapid motion of the molecule may cause its escape.

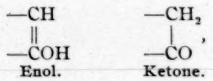
It is evident that in this way entire homologous series of carbon compounds could be built up.

Since the positive charge has never been found detached from a mass less than a hydrogen atom, and since we do not know fractions of atoms, in inductive action substitution will take place only when a charge equivalent to that of a hydrogen atom has been repelled from the neutral molecule.

Suppose, however, the inducing body has not power sufficient to expel a charge equivalent to that of a hydrogen ion, substitution cannot take place, but there will still be effects due to induction.

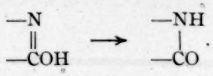
Suppose, for example, a molecule is so constituted that no hydrogen ion, or its equivalent, is free to escape from the molecule, but the only constituent free to move is an elec-

tron. While substitution does not take place, a state of strain would be set up; there would be a weakening or breaking of bonds due to the redistribution of atoms, necessitated by induction. Or, we may consider that there is a redistribution of atoms caused by the breaking of bonds. This might explain the tautomeric behavior of certain chemical compounds. Using the *enol-ketone* illustration,



inductive action, causing a rearrangement of the atoms within the molecule and the expulsion of an electron, might produce strain enough to break the double bond joining the two carbon atoms.

We see, on examination, that the rearrangement of the atoms is just such as would take place in the distribution of the two kinds of electricity in a neutral body by induction. The positive hydrogens all go to one carbon, while the negative oxygen remains attached to the other carbon. We find the same condition in the *lactime* form of tautomerism,



The objection urged against the Berzelius electrochemical theory applies also to inductive action, viz., that hydrogen atoms are replaced by negative atoms. It is, however, well known that Sir J. J. Thomson, by brilliant experimental work, has overthrown this objection. We must, therefore, think of positively charged chlorine and negatively charged chlorine, positive methyl and negative methyl, etc. We can readily see that the effect produced in the molecule by a positively charged methyl group, acting as the inducing body, would be entirely different from that produced by a negatively charged methyl group.

The resultant molecule could be represented by the same chemical formula, but it is evident that the *arrangement* of

atoms in the two would be different, giving rise to isomeric forms.

When we consider the close connection between isomerism, polarized light and electricity, knowing as we do that rotation of the beam of polarized light is dependent in some way upon a strain in the ether in the interior of the molecule, inductive action seems to be a condition under which such a strain and, consequently, the rotation of the beam of polarized light, might be produced.

Isomeric forms can, of course, be produced in other ways. For example, compounds formed by any of the following methods could have the same formulae:

(1) Polymerization of radicals having different charges.

(2) Interchange of ions, as in ordinary inorganic reactions.

(3) Substitution by means of inductive action.

Thus far we have dealt with saturated compounds. How do unsaturated differ from saturated compounds in their method of formation?

Suppose a body, *A*, charged with positive electricity, is separated by a nonconducting medium from a neutral body, *B*. The electricities in *B* become separated. If, while *A*, the charged body, is still present, the repelled charge in *B* is removed by contact or motion, *B* is left negatively charged. If *A* is near it may be drawn into *B* and *B* becomes neutral again. This happens in the case of saturated compounds.

If, on the other hand, *A*, the charged body, is too heavy or at too great a distance to be drawn into *B*, or if it moves away before it can be drawn into *B*, then *B* will remain a charged body, i. e., it becomes an unsaturated compound, and it will be able to form addition products; and this is characteristic of unsaturated compounds. These unsaturated molecules combining would also give rise to polymers.

The idea of induction seems to account for the variable valences of some of the elements, as will now be seen. Some elements, we have reason to believe, lose electrons more readily than others. These elements, having formed compounds, like other elements would be peculiarly sensitive to the inductive action of a charged ion. Electrons would be easily repelled

from them, and they would again become capable of attaching other elements to themselves.

There is a limit, of course, to the number of electrons that could be repelled, since the loss of an electron would leave the molecule more strongly positive, which would tend to keep more electrons from escaping.

If this suggestion is true, the tendency to manifest different valences would be shown chiefly by the more electronegative elements, by those having a large atomic weight, and by those having small atomic volume. The reasons for the above are quite obvious. An electronegative element would be more likely to repel the negative electron. A large atomic weight probably means a large number of electrons, and the larger the number the more easily would some be lost. These conditions are quite strikingly illustrated in the elements manifesting different valences, such as chlorine, phosphorus, iodine, nitrogen, sulphur, oxygen, etc. In the curve produced by plotting atomic volumes as ordinates against atomic weights as abscissae, the very lowest points on the curve, those representing the smallest atomic volumes, are occupied by carbon, manganese, cobalt, nickel, copper, iron, and chromium. This seems quite significant in the light of the explanation just given.

Let us now attempt to apply this idea to catalysis.

The function of a catalyzer may be:

(1) To remove the repelled electricity, where the removal is essential to the electrification of the molecule, and consequent drawing in to itself of the radical or ion. A third body may be necessary here, as in the case of ordinary electrostatic induction, on account of the small velocity of the molecule.

(2) The catalyzer may serve to ionize one of the reagents and thus make the reaction continuous, which, for lack of ions, had been impossible.

(3) The catalyzer, dissociating, may by its charge help to draw the repelled charge (which cannot escape of itself) out of the molecule. It may render some bond easier to be broken, and thus make possible an entrance of an atom or group otherwise impossible.

(4) The charged body may not be near enough to the neutral body to bring about induction and, consequently, some carrier may be necessary.

(5) The charged body may be too heavy to be drawn into the neutral body without a carrier.

(6) The catalyzer may serve to break up an equilibrium which otherwise would exist.

(7) The catalyzer may tend to keep the undissociated molecule from dissociating.

The reaction may not be possible from mere union of differently charged ions—but entirely dependent on induction. In such case the molecule must be kept undissociated and neutral.

The fact that the conditions best suited to induction belong to organic chemistry, together with the fact that so many of the characteristics of organic compounds can be explained by the above suggestions, would seem to indicate that it is worthy of consideration.

It is true that difficulties arise in the application of induction to chemical reaction, but it undoubtedly helps to explain many things hitherto unexplained.

The foregoing presents but a bare outline of the part played by induction in chemical reaction.

Many other chemical phenomena can probably be explained by it. Among these are *steric hindrance*, and the fact that conductivity is not a true measure of dissociation in concentrated solutions, but a more detailed consideration of the subject will be given later.

PHYSICAL CHEMICAL LABORATORY,
JOHNS HOPKINS UNIVERSITY,
March, 1911.

THE RELATION OF OSMOTIC PRESSURE TO TEMPERATURE.[1]

PART V.—THE MEASUREMENTS.

By H. N. Morse, W. W. Holland, E. G. Zies, C. N. Myers, W. M. Clark and E. E. Gill.

The material for the measurements here presented was purified essentially by the method described by Cohen and Commelin.[2] One hundred and fifty pounds, approximately 70 kilograms, of the best "rock candy" were procured and subjected to the treatment which will be briefly described. Kilogram quantities of the sugar were dissolved, each in 500 cc. of boiled distilled water, which was warmed, but not allowed to rise above 60°. The solution (sometimes thinned with a little alcohol) was filtered, and from the filtrate the sugar was precipitated by alcohol which had been distilled from lime, a few crystals of the purest sugar being used to start the precipitation. The precipitated sugar was collected on a perforated porcelain disk in the bottom of a glass funnel. After removing all the mother liquor which could be drawn off by means of the filter pump, the material was transferred from the funnel to a porcelain dish and mixed to a thin paste with 85 per cent. alcohol. Finally, it was again filtered and then nearly dried by drawing through it filtered air. The original material and the product of the first precipitation will be designated hereafter by the letters *A* and *B*. The yield of *B* was about 32 kilograms.

The various portions of *B* were thoroughly mixed and then subjected to the treatment which has already been described, except that the precipitated material, after having been washed with diluted ethyl alcohol, was again washed in the same manner with warm methyl alcohol. The product, which will be designated by the letter *C*, amounted to about 16 kilograms.

[1] The work upon osmotic pressure which is in progress in this laboratory is aided by grants from the Carnegie Institution. The papers upon this subject which have preceded the present one will be found in This Journal, **20**, 80; **28**, 1; **29**, 137; **32**, 93; **34**, 1; **36**, 1 and 39; **37**, 324, 425 and 558; **38**, 175; **39**, 667; **40**, 1, 194, 266 and 325; **41**, 1, 92 and 557; **45**, 91, 237, 383, and 517.

[2] Z. physik. Chem., **64**, 1.

A portion of the sugar (*C*) which had been twice precipitated was again dissolved, reprecipitated, and washed with both ethyl and methyl alcohols. The product of the third precipitation will be designated by the letter *D*.

Combustions were made of all four products, namely *A*, the original rock candy; *B*, which had been precipitated once; *C*, twice; and *D*, three times. The results are given below in percentages of hydrogen and carbon.

	A.		*B.*		*C.*		*D.*	
	H	C	H	C	H	C	H	C
1	6.432	42.156	6.436	42.116	6.466	42.151	6.484	42.047
2	6.495	42.081	6.451	42.059	6.420	42.081	6.487	42.031
3	6.477	42.099	6.465	42.151	6.471	42.116	6.485	42.101
Mean	6.468	42.112	6.451	42.109	6.452	42.116	6.485	42.060
Theoret.	6.481	42.083	6.481	42.083	6.481	42.083	6.481	42.083
Dif.	—0.013	+0.029	—0.030	+0.026	—0.029	+0.033	—0.004	—0.023

The difference between the percentages of hydrogen and carbon which were found and the theoretical values are all within the unavoidable errors of analysis; and there is no reason to be found in the figures given above for believing one sample to be better than another. A determination of carbon and hydrogen does not, however, suffice for the detection of small quantities of glucose or invert sugar in cane sugar; and the probable presence of some reducing sugars could be detected in all of the samples. Much work was done in attempts to establish the limits within which these might be present. Finally, however, the whole question was referred to the National Bureau of Standards at Washington. The report which was received from the Bureau is given below:

Sample A.—Reducing substances in terms of invert sugar, 0.08 per cent. ±0.005 per cent.

Sample B.—Reducing substances in terms of invert sugar, 0.01 per cent. ±0.005 per cent.

Sample C.—Polarization, 99°.93. Reducing substances in terms of invert sugar, 0.01 per cent. ±0.005 per cent.

Sample D.—Polarization, 99°.95. Reducing substances in terms of invert sugar, 0.005, per cent. ±0.005 per cent.

The material which has been employed in the present investigation is that which is designated by the letter *C*, in which the Bureau of Standards found 0.01 per cent. of reducing sugar. The sample *D*, which had been recrystallized three times, is doubtless somewhat purer; but, as we have remarked elsewhere, *uniformity* of material is more important than absolute purity when a temperature coefficient is to be determined, and we feared that if the whole of the 16 kilograms of sample *C* were subjected to recrystallization, the product would not suffice for all of the work we had planned to do.

We have stated in a previous paper that, notwithstanding the extended investigation to which the manometers were subjected, we were not altogether satisfied with these instruments. It is to be said of them, however, that, as originally prepared for the investigation, they showed a high degree of concordance among themselves, which is all that is essential in determining a temperature coefficient. Toward the close of the work, three of the manometers (Numbers 11, 22 and 24) were opened and refilled with larger volumes of nitrogen with a view to diminishing the error of meniscus. As the gas now more than filled the calibrated portions of the tubes under ordinary pressure, it was necessary to determine its volume under increased pressure, and to use for this purpose the so-called "standard manometer" as a "side tube." It soon appeared, however, that we knew too little about the variations of capillary depression in the standard instrument. In other words, the volumes of the gas reduced to standard conditions appeared to vary somewhat according to the pressures under which they were determined. The refilled manometers were discarded after having been used in eight experiments, and, in order that there might be no uncertainty as to the results, the experiments in which they had been used were all repeated, at least twice, with other manometers which had not been refilled and which were known to be concordant among themselves.

For the first time, another membrane than copper ferrocyanide appears among the measurements of osmotic pressure.

Four of the determinations reported in this paper—Numbers XII, XIII, XV and XVIII—were made with membranes of nickel ferrocyanide. It was found long ago[1] that a considerable number of osmotically active membranes could be readily produced by the electrolytic process; but, though 25 of these have been made and tested qualitatively, we could not, until recently, spare the cells for the purpose of testing their suitability for quantitative work. The ferrocyanide of nickel appears to be superior in some respects to the corresponding salt of copper, but a comparison of the two will be withheld until a more thorough study of the former has been made.

Some of the experimental details which were given in the earlier communications in tabular form are omitted in this paper, because they can now be covered by general statements.

There was *no loss or gain in rotation* in any of the solutions whose pressures are reported, therefore none of the experiments are vitiated in consequence of leakage through the membranes. A number of the cells which were set up in the course of the investigation were found to be in a leaky condition—usually in consequence of infection which had escaped notice; but all experiments in which the slightest loss in concentration could be detected by the polariscope were rejected. Since the rotations of the solutions remained constant, it is clear that no *inversion* of the cane sugar occurred in the cells.

A solution sometimes *concentrates in the cell.* This happens whenever the solution is at a lower temperature than the bath at the time of filling and closing the cell. On being placed in the warmer bath, the solution expands, producing an over-pressure which forces some of the solvent outward through the membrane. Obviously, experiments in which such a concentration has taken place need not be rejected if one has the means of determining the precise amount of the concentration. Cells in which concentration has occurred give ultimately just as constant osmotic pressures as

[1] This Journal, **29**, 173.

those whose concentration has remained unchanged. *Concentration* of the kind described occurred in three instances in the course of the present investigation. The experiments are not included in this paper, though the results are valid and in perfect conformity with those which are reported. At moderate temperatures, e. g., below 40°, it is practicable to avoid a concentration of the kind described; for the cell may be filled, closed, and transferred to the bath without any sensible drop in the temperature of the solution. But at higher temperatures it is often necessary to determine the concentration of the solution whose pressure has been measured *after* the cell has been removed from the bath.

A solution may become *diluted* in a cell *without any leakage of the membrane*, and despite the fact that a mechanical pressure equal to the osmotic pressure is brought upon it at the time of closing the cell. This occurs when the solution at the time of filling the cell is at a higher temperature than that of the bath in which it is afterwards to stand. Such diluted solutions exhibit constant osmotic pressures, and the measurements are perfectly satisfactory if the exact degree of the dilution can be determined and *provided it can be demonstrated also that no part of the dilution was due to a break in the membrane which was afterwards effectually mended by the membrane formers*. The latter condition can rarely be fulfilled, hence it is safe to reject all experiments in which a dilution of the cell contents has occurred.

Especial attention is called to Experiment No. LXXIII, which was intended to serve as an *endurance* test of our membranes. The cell was not selected for this purpose because the membrane was supposed to be an unusually good one, but because at the time of setting up the cell we were able to spare the manometer and the bath for a long period of time. We have no reason for believing that any other cell employed in the 147 experiments to be reported would have made a less satisfactory record under the same conditions. The cell was set up on Jan. 24 with a 0.5 weight-normal solution at 15°. On Jan. 25 the mean osmotic pressure for the day was 12.522 atmospheres, the mean atmospheric pressure

being 1.013. On March 25, the 60th day thereafter, the mean pressure for the day was also 12.522 atmospheres, the mean atmospheric pressure being 1.016. The lowest osmotic pressure observed during the entire two months was 12.517 atmospheres, while the highest was 12.552. The extreme (apparent) fluctuation in osmotic pressure was therefore 0.035 atmosphere. The extreme variation in atmospheric pressure during the same time was 1.0175 — 0.986 = 0.0315 atmosphere. In other words, the extreme (apparent) fluctuations in osmotic pressure were very nearly identical with those of the atmosphere. The highest osmotic pressures are contemporaneous with the lowest atmospheric pressures, and *vice versa*; and throughout the entire record, the fluctuations of osmotic and atmospheric pressures are of opposite signs. This is due, of course, to the fact that the pressure within the cell cannot instantaneously adjust itself to a change in atmospheric pressure, because the solvent *requires time* for its passage, inward or outward, through the membrane. It is for this reason that we regard it as probably more rational to employ mean values in correcting for atmospheric pressure. However, errors due to the opposite practice of correcting each observation for the atmospheric pressure prevailing at the time of reading tend to eliminate one another, so that the final mean osmotic pressure which is arrived at is probably very nearly correct, despite the fluctuations in atmospheric pressure. In the present case, the mean osmotic pressure for the 60 days is 12.5326 atmospheres, whichever method of correcting for atmospheric pressure is adopted. The apparent slight fluctuations in osmotic pressure are in reality only barometer effects. Thermometer effects played but a small part in this long-time experiment, for during the entire two months the temperature of the bath did not vary more than 0°.01.

On opening the cell on the 60th day, the rotation of the solution was found to be identical with that of the original one, showing that the solution had suffered no change in concentration, also that *no inversion of the cane sugar had occurred.*

The conduct of this cell, which maintained the concentra-

tion of its solution and a consequent osmotic pressure for more than eight weeks without the slightest evidence of approaching failure, proves, we think, first that our membranes are fulfilling their purpose in a satisfactory manner; and, secondly, that, under the conditions prevailing in our work, *the stirring of the solutions is unnecessary*. It appears to prove also that osmotically active membranes *may be made truly semipermeable*, a fact which is often denied, apparently on the basis of no better evidence than the fact that the products of most attempts at membrane-making are found to be leaky.

The whole subject of temperature maintenance during the present investigation can be covered in a few words. The temperature of the solutions did not vary during any experiment more than 0°.02. The usual fluctuations were certainly less than 0°.01. It is to be stated, however, by way of qualification, that in two or three instances a temporary drop in temperature exceeding 0°.02 occurred in consequence of accidents to the regulating devices, but in such cases the solutions were given ample time for recovery before the readings of the pressures were recorded. The thermometer effects throughout the entire work were very small. The fluctuations in pressure which will be noted in the following tables are, as in the case of Experiment LXXIII, already alluded to, principally barometer effects. The temperatures of the manometers (the "air space") were nearly equally satisfactory, except in the experiments at 0°, where the temperature of the space occupied by the gas-filled ends of these instruments was usually from 0°.1 to 0°.3 above 0°.

In Tables I to CXLVII, inclusive, there are given for each experiment: the concentration and temperature of the solution; the cell and the manometer which were used; the resistance of the membrane; the calculated gas pressure of the dissolved material at the same temperature if its volume were that of the solvent; the time of setting up the cell; and, finally, the osmotic pressures which were observed.

In Table CXLVIII, the results of the individual experiments are brought together, and there is given for each concentration and temperature: the osmotic pressure found;

the mean osmotic pressure; and the ratio of the mean to the calculated gas pressure.

Table CXLIX gives the mean osmotic pressure for each concentration and temperature; and Table CL, the ratio of these means to the calculated gas pressures.

Table I.

0.1 Wt. normal solution. Expt. 1 at 0°. Cell K_3. Resistance of membrane, 545,000 ohms. Manometer 13. Calc. gas pressure, 2.227 atms. Time of setting up cell, Mar. 8, 1909, 12.30 P.M. Initial pressure, 2.2 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 9, 10.00 A.M.	2.462	Mar. 9, 5.00 P.M.	2.460
2.00 P.M.	2.461	10, 12.30 P.M.	2.456
		Mean,	2.460

Table II.

0.1 Wt. normal solution. Expt. 2 at 0°. Cell K_3. Resistance of membrane, 224,000 ohms. Manometer 6. Calc. gas pressure, 2.227 atms. Time of setting up cell, April 12, 1909, 12.00 M. Initial pressure, 2.0 atms. Observed osmotic pressures:

	Atms.		Atms.
April 13, 10.00 A.M.	2.466	April 13, 9.30 A.M.	2.464
5.00 P.M.	2.465	14, 9.00 A.M.	2.460
		Mean,	2.464

Table III.

0.1 Wt. normal solution. Expt. 3 at 0°. Cell K_3. Resistance of membrane, 226,000 ohms. Manometer 6. Calc. gas pressure, 2.227 atms. Time of setting up cell, April 29, 1909, 3.00 P.M. Initial pressure, 2.3 atms. Observed osmotic pressures:

	Atms.		Atms.
April 30, 10.00 A.M.	2.465	April 30, 10.00 P.M.	2.460
5.00 P.M.	2.465	May 1, 10.00 A.M.	2.460
		Mean,	2.463
		Mean of experiments 1, 2 and 3,	2.462
		Ratio of osmotic to gas pressure,	1.106

Table IV.

0.1 Wt. normal solution. Expt. 1 at 5°. Cell K_3. Resistance of membrane, 366,000 ohms. Manometer 13. Calc. gas pressure, 2.267 atms. Time of setting up cell, Feb. 22, 1909, 3.00 P.M. Initial pressure, 2.3 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 23, 12.30 P.M.	2.455	Feb. 24, 9.00 A.M.	2.450
5.00 P.M.	2.455	1.00 P.M.	2.447
		Mean,	2.452

Table V.

0.1 Wt. normal solution. Expt. 2 at 5°. Cell L_3. Resistance of membrane, 550,000 ohms. Manometer 6. Calc. gas pressure, 2.267 atms. Time of setting up cell, Feb. 22, 1909, 3.00 P.M. Initial pressure, 2.39 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 23, 5.30 P.M.	2.453	Feb. 24, 10.00 A.M.	2.447
9.00 P.M.	2.452	2.00 P.M.	2.450
		Mean,	2.451

Table VI.

0.1 Wt. normal solution. Expt. 3 at 5°. Cell J_3. Resistance of membrane, 228,000 ohms. Manometer 13. Calc. gas pressure, 2.267 atms. Time of setting up cell, Feb. 25, 1909, 3.00 P.M. Initial pressure, 2.36 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 26, 10.00 A.M.	2.453	Feb. 27, 1.00 P.M.	2.456
4.30 P.M.	2.454	9.00 P.M.	2.448
		Mean,	2.453
		Mean of experiments 1, 2 and 3,	2.452
		Ratio of osmotic to gas pressure,	1.082

Table VII.

0.1 Wt. normal solution. Expt. 1 at 10°. Cell K_3. Resistance of membrane, 160,000 ohms. Manometer 13. Calc. gas pressure, 2.308 atms. Time of setting up cell, Mar. 1, 1909, 1.00 P.M. Initial pressure, 2.35 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 2, 9.00 A.M.	2.495	Mar. 2, 5.00 P.M.	2.493
1.00 P.M.	2.497	3, 9.00 A.M.	2.491
		Mean,	2.494

Table VIII.

0.1 Wt. normal solution. Expt. 2 at 10°. Cell N_3. Resistance of membrane, 133,000 ohms. Manometer 11. Calc. gas pressure, 2.308 atms. Time of setting up cell, Mar. 9, 1909, 12.30 P.M. Initial pressure, 2.40 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 9, 10.00 P.M.	2.500	Mar. 10, 12.30 P.M.	2.492
10, 10.00 A.M.	2.498	10.00 A.M.	2.494
		Mean,	2.496

Table IX.

0.1 Wt. normal solution. Expt. 3 at 10°. Cell O_3. Resistance of membrane, 151,000 ohms. Manometer 20. Calc. gas pressure, 2.308 atms. Time of setting up cell, Mar. 9, 1909, 12.30 P.M. Initial pressure, 2.43 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 9, 10.00 P.M.	2.492	Mar. 10, 4.00 P.M.	2.501
10, 10.00 A.M.	2.508	11, 9.30 A.M.	2.508
		Mean,	2.502

Table X.

0.1 Wt. normal solution. Expt. 4 at 10°. Cell J_3. Resistance of membrane, 176,000 ohms. Manometer 6. Calc. gas pressure, 2.308 atms. Time of setting up cell, Mar. 9, 1909, 12.30 P.M. Initial pressure, 2.41 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 10, 10.00 A.M.	2.503	Mar. 10, 4.00 P.M.	2.495
12.30 P.M.	2.498	10.00 P.M.	2.496
		Mean,	2.498
		Mean of experiments 1, 2, 3 and 4,	2.498
		Ratio of osmotic to gas pressure,	1.082

Table XI.

0.1 Wt. normal solution. Expt. 1 at 15°. Cell F_8. Resistance of the membrane, 225,000 ohms. Manometer 20. Calc. gas pressure, 2.349 atms. Time of setting up cell, Feb. 7, 1911, 2.00 P.M. Initial pressure, 2.4 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 11	2.551	Feb. 13	2.544
12	2.553	14	2.540
		Mean,	2.547

Table XII.

0.1 Wt. normal solution. Expt. 2 at 15°. Cell Ni–$_2$. Resistance of membrane,[1] 70,000 ohms. Manometer 9. Calc. gas pressure, 2.349 atms. Time of setting up cell, Jan. 13, 1911, 1.00 P.M. Initial pressure, 2.466 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 15	2.528	Jan. 17	2.538
16	2.538	18	2.535
		Mean,	2.535

Table XIII.

0.1 Wt. normal solution. Expt. 3 at 15°. Cell Ni–$_3$. Resistance of membrane,[1] 104,000 ohms. Manometer M_1. Calc. gas pressure, 2.349 atms. Time of setting up cell, Feb. 18, 1911, 12.00 M. Initial pressure, 2.315 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 19	2.544	Feb. 21	2.536
20	2.547	22	2.537
		Mean,	2.541

Table XIV.

0.1 Wt. normal solution. Expt. 4 at 15°. Cell Ni–$_2$. Resistance of membrane,[1] 112,000 ohms. Manometer 9. Calc. gas pressure, 2.349 atms. Time of setting up cell, Feb. 21, 1911, 3.00 P.M. Initial pressure, 2.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 22	2.532	Feb. 26	2.546
23	2.535	27	2.538
24	2.548	28	2.535
25	2.545	Mar. 1	2.530
		Mean,	2.538
		Mean of experiments 1, 2, 3 and 4	2.540
		Ratio of osmotic to gas pressure,	1.082

Table XV.

0.1 Wt. normal solution. Expt. 1 at 20°. Cell T_3. Resistance of membrane, 350,000 ohms. Manometer 9. Calc. gas pressure, 2.390 atms. Time of setting up cell, Mar. 7, 1910, 4.00 P.M. Initial pressure, 2.1 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 9, 9.00 A.M.	2.597	Mar. 9, 4.00 P.M.	2.579
12.30 P.M.	2.594	10, 9.00 A.M.	2.586
		Mean,	2.589

[1] Nickel ferrocyanide.

Table XVI.

0.1 Wt. normal solution. Expt. 2 at 20°. Cell I_3. Resistance of membrane, 150,000 ohms. Manometer 15. Calc. gas pressure, 2.390 atms. Time of setting up cell, Mar. 7, 1910, 4.00 P.M. Initial pressure, 2.2 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 9, 9.00 A.M.	2.591	Mar. 10, 1.00 P.M.	2.589
10, 9.00 A.M.	2.589	5.00 P.M.	2.591
		Mean,	2.590
		Mean of experiments 1 and 2,	2.590
		Ratio of osmotic to gas pressure,	1.084

Table XVII.

0.1 Wt. normal solution. Expt. 1 at 25°. Cell T_3. Resistance of membrane, 367,000 ohms. Manometer 9. Calc. gas pressure, 2.431 atms. Time of setting up cell, Feb. 23, 1910, 4.00 P.M. Initial pressure, 2.3 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 26, 9.00 A.M.	2.631	Feb. 27, 10.00 A.M.	2.642
1.00 P.M.	2.633		
5.00 P.M.	2.634	Mean,	2.635

Table XVIII.

0.1 Wt. normal solution. Expt. 2 at 25°. Cell Ni_2. Resistance of membrane,[1] 65,000 ohms. Manometer 9. Calc. gas pressure, 2.431 atm. Time of setting up cell, Jan. 6, 1911, 2.00 P.M. Initial pressure, 2.639 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 7, 9.00 A.M.	2.639	Jan. 8, 9.00 A.M.	2.633
5.00 P.M.	2.620	10.00 A.M.	2.634
10.00 P.M.	2.627	8.00 P.M.	2.638
		Mean,	2.632
		Mean of experiments 1 and 2,	2.634
		Ratio of osmotic to gas pressure,	1.084

Table XIX.

0.2 Wt. normal solution. Expt. 1 at 0°. Cell Z_3. Resistance of membrane, 290,000 ohms. Manometer 5. Calc. gas pressure, 4.453 atms. Time of setting up cell, April 5, 1909, 3.00 P.M. Initial pressure, 4.6 atms. Observed osmotic pressures:

	Atms.		Atms.
April 6, 10.00 A.M.	4.721	April 7, 11.00 A.M.	4.719
5.00 P.M.	4.718		
10.00 P.M.	4.718	Mean,	4.719

[1] Nickel ferrocyanide.

Table XX.

0.2 Wt. normal solution. Expt. 2 at 0°. Cell K_3. Resistance of membrane, 193,000 ohms. Manometer 6. Calc. gas pressure, 4.453 atms. Time of setting up cell, April 5, 1909, 3.00 P.M. Initial pressure, 4.5 atms. Observed osmotic pressures:

	Atms.		Atms.
April 6, 11.00 A.M.	4.712	April 7, 12.00 M.	4.720
5.00 P.M.	4.715		
10.00 P.M.	4.720	Mean,	4.717

Table XXI.

0.2 Wt. normal solution. Expt. 3 at 0°. Cell Q_3. Resistance of membrane, 220,000 ohms. Manometer 6. Calc. gas pressure, 4.453 atms. Time of setting up cell, April 14, 1909, 4.00 P.M. Initial pressure, 4.7 atms. Observed osmotic pressures:

	Atms.		Atms.
April 15, 10.00 A.M.	4.738	April 16, 10.00 A.M.	4.727
5.00 P.M.	4.729		
9.30 P.M.	4.725	Mean,	4.730

Table XXII.

0.2 Wt. normal solution. Expt. 4 at 0°. Cell M_3. Resistance of membrane, 278,000 ohms. Manometer 6. Calc. gas pressure, 4.453 atms. Time of setting up cell, April 16, 1909, 3.00 P.M. Initial pressure, 4.6 atms. Observed osmotic pressures:

	Atms.		Atms.
April 17, 10.30 A.M.	4.725	April 18, 5.00 P.M.	4.727
2.00 P.M.	4.727		
6.00 P.M.	4.725	Mean,	4.726
		Mean of experiments 1, 2, 3 and 4,	4.722
		Ratio of osmotic to gas pressure,	1.061

Table XXIII.

0.2 Wt. normal solution. Expt. 1 at 5°. Cell F_3. Resistance of membrane, 565,000 ohms. Manometer 6. Calc. gas pressure, 4.535 atms. Time of setting up cell, Jan. 25, 1909, 3.00 P.M. Initial pressure, 4.55 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 27, 9.00 A.M.	4.813	Jan. 28, 9.00 A.M.	4.812
11.00 P.M.	4.816	4.00 P.M.	4.807
		Mean,	4.812

Table XXIV.

0.2 Wt. normal solution. Expt. 2 at 5°. Cell J_3. Resistance of membrane, 270,000 ohms. Manometer 9. Calc. gas pressure, 4.535 atms. Time of setting up cell, Feb. 17, 1909, 12.00 M. Initial pressure, 4.7 atms. Observed osmotic pressures:

		Atms.			Atms.
Feb. 18,	9.00 A.M.	4.830	Feb. 19,	12.30 P.M.	4.820
	10.00 P.M.	4.825		5.00 P.M.	4.823
				Mean,	4.825
		Mean of experiments 1 and 2,			4.818
		Ratio of osmotic to gas pressure,			1.063

Table XXV.

0.2 Wt. normal solution. Expt. 1 at 10°. Cell H_3. Resistance of membrane, 100,000 ohms. Manometer 13. Calc. gas pressure, 4.616 atms. Time of setting up cell, Mar. 15, 1909, 12.30 P.M. Initial pressure, 4.73 atms. Observed osmotic pressures:

		Atms.			Atms.
Mar. 16,	9.00 A.M.	4.892	Mar. 17,	9.00 A.M.	4.889
	5.30 P.M.	4.892		2.00 P.M.	4.888
				Mean,	4.890

Table XXVI.

0.2 Wt. normal solution. Expt. 2 at 10°. Cell I_3. Resistance of membrane, 125,000 ohms. Manometer 20. Calc. gas pressure, 4.616 atms. Time of setting up cell, Mar. 15, 1909, 12.30 P.M. Initial pressure, 4.13 atms. Observed osmotic pressures:

		Atms.			Atms.
Mar. 16,	9.00 A.M.	4.901	Mar. 17,	9.00 A.M.	4.891
	5.00 P.M.	4.898			
	10.00 P.M.	4.895		Mean,	4.896
		Mean of experiments 1 and 2,			4.893
		Ratio of osmotic to gas pressure,			1.060

Table XXVII.

0.2 Wt. normal solution. Expt. 1 at 15°. Cell I_3. Resistance of membrane, 190,000 ohms. Manometer 6. Calc. gas pressure, 4.698 atms. Time of setting up cell, Feb. 2, 1911, 3.00 P.M. Initial pressure, 4.6 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 12	4.994	Feb 14	4.974
13	4.978	15	4.979
		Mean,	4.981

Table XXVIII.

0.2 Wt. normal solution. Expt. 2 at 15°. Cell R_3. Resistance of membrane, 550,000 ohms. Manometer 22. Calc. gas pressure, 4.698 atms. Time of setting up cell, Feb. 4, 1911, 10.00 A.M. Initial pressure, 5.03 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 16	5.003	Feb. 20	4.992
17	4.996	21	4.974
18	5.000	22	4.980
19	4.988	23	4.973
		Mean,	4.988
		Mean of experiments 1 and 2,	4.985
		Ratio of osmotic to gas pressure,	1.061

Table XXIX.

0.2 Wt. normal solution. Expt. 1 at 20°. Cell R_3. Resistance of membrane, 100,000 ohms. Manometer 20. Calc. gas pressure, 4.78 atms. Time of setting up cell, Mar. 12, 1910, 12.00 M. Initial pressure, 4.6 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 14, 10.00 A.M.	5.053	Mar. 15, 10.00 A.M.	5.052
1.00 P.M.	5.058		
5.00 P.M.	5.059	Mean,	5.056

Table XXX.

0.2 Wt. normal solution. Expt. 2 at 20°. Cell Q_3. Resistance of membrane, 180,000 ohms. Manometer 15. Calc. gas pressure, 4.78 atms. Time of setting up cell, Mar. 12, 1910, 12.00 M. Initial pressure, 4.8 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 15, 10.00 A.M.	5.066	Mar. 16, 1.00 P.M.	5.069
12.30 P.M.	5.068	10.00 P.M.	5.061
11.00 P.M.	5.067		
		Mean,	5.066

Table XXXI.

0.2 Wt. normal solution. Expt. 3 at 20°. Cell A_3. Resistance of membrane, 140,000 ohms. Manometer 9. Calc. gas pressure, 4.78 atms. Time of setting up cell, Dec. 15, 1910, 12.00 M. Initial pressure, 4.89 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 23	5.080	Dec. 29	5.062
24	5.086	30	5.058
25	5.071	31	5.035
26	5.060	Jan. 1	5.033
27	5.061	2	5.035
28	5.070	3	5.042
		Mean,	5.058

Table XXXII.

0.2 Wt. normal solution. Expt. 4 at 20°. Cell G_3. Resistance of membrane, 120,000 ohms. Manometer 24. Calc. gas pressure, 4.78 atms. Time of setting up cell, Dec. 22, 1910, 12.00 M. Initial pressure, 5.03 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 25	5.052	Dec. 28	5.065
26	5.080	29	5.060
27	5.078	30	5.054
		Mean,	5.065

Table XXXIII.

0.2 Wt. normal solution. Expt. 5 at 20°. Cell E_3. Resistance of membrane, 160,000 ohms. Manometer 15. Calc. gas pressure, 4.78 atms. Time of setting up cell, Dec. 22, 1910, 12.00 M. Initial pressure, 5.05 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 26	5.093	Dec. 31	5.061
27	5.079	Jan. 1	5.064
28	5.081	2	5.083
29	5.076	3	5.085
30	5.074		
		Mean,	5.074
		Mean of experiments 1, 2, 3, 4 and 5,	5.064
		Ratio of osmotic to gas pressure,	1.062

Table XXXIV.

0.2 Wt. normal solution. Expt. 1 at 25°. Cell A_4. Resistance of membrane, 560,000 ohms. Manometer 9. Calc. gas pressure, 4.862 atms. Time of setting up cell, Feb. 12, 1910, 12.00 M. Initial pressure, 4.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 13, 11.00 A.M.	5.160	Feb. 16, 5.00 P.M.	5.152
1.00 P.M.	5.152	2.00 P.M.	5.153
		Mean,	5.154

Table XXXV.

0.2 Wt. normal solution. Expt. 2 at 25°. Cell Q_2. Resistance of membrane, 180,000 ohms. Manometer 9. Calc. gas pressure, 4.862 atms. Time of setting up cell, Feb. 28, 1910, 12.00 M. Initial pressure, 4.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 3, 9.00 A.M.	5.142	Mar. 3, 4.30 P.M.	5.139
1.00 P.M.	5.143	10.00 P.M.	5.133
		Mean,	5.139

Table XXXVI.

0.2 Wt. normal solution. Expt. 3 at 25°. Cell M_4. Resistance of membrane, 535,000 ohms. Manometer 11. Calc. gas pressure, 4.862 atms. Time of setting up cell, Feb. 28, 1910, 12.00 M. Initial pressure, 4.7 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 1, 9.00 A.M.	5.162	Mar. 2, 9.00 A.M.	5.144
2.00 P.M.	5.157	9.00 P.M.	5.137
		Mean,	5.150
		Mean of experiments 1, 2 and 3,	5.148
		Ratio of osmotic to gas pressure,	1.059

Table XXXVII.

0.3 Wt. normal solution. Expt. 1 at 0°. Cell M_4. Resistance of membrane, 224,000 ohms. Manometer 11. Calc. gas pressure, 6.680 atms. Time of setting up cell, Mar. 15, 1909, 3.00 P.M. Initial pressure, 6.75 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 16, 2.00 P.M.	7.083	Mar. 17, 10.00 A.M.	7.073
10.00 P.M.	7.082	5.00 P.M.	7.074
		Mean,	7.078

Table XXXVIII.

0.3 Wt. normal solution. Expt. 2 at 0°. Cell M_3. Resistance of membrane, 224,000 ohms. Manometer 11. Calc. gas pressure, 6.680 atms. Time of setting up cell, April 2, 1909, 3.00 P.M. Initial pressure, 7.0 atms. Observed osmotic pressures:

		Atms.			Atms.
April 3,	1.00 P.M.	7.113	April 4,	6.00 P.M.	7.107
4,	12.00 M.	7.105	5,	10.00 A.M.	7.102
				Mean,	7.107

Table XXXIX.

0.3 Wt. normal solution. Expt. 3 at 0°. Cell M_3. Resistance of membrane, 185,000 ohms. Manometer 6. Calc. gas pressure, 6.680 atms. Time of setting up cell, April 20, 1909, 3.00 P.M. Initial pressure, 7.00 atms. Observed osmotic pressures:

		Atms.			Atms.
April 21,	5.00 P.M.	7.067	April 22,	10.00 A.M.	7.073
	10.30 P.M.	7.068		2.00 P.M.	7.074
				Mean,	7.071
			Mean of experiments 1, 2 and 3,		7.085
			Ratio of osmotic to gas pressure,		1.061

Table XL.

0.3 Wt. normal solution. Expt. 1 at 5°. Cell J_3. Resistance of membrane, 366,000 ohms. Manometer 6. Calc. gas pressure, 6.862 atms. Time of setting up cell, Jan. 28, 1909, 3.30 P.M. Initial pressure, 5.66 atms. Observed osmotic pressures:

		Atms.			Atms.
Jan. 29,	5.00 P.M.	7.190	Jan. 30,	10.00 A.M.	7.187
	11.00 P.M.	7.187		1.00 P.M.	7.185
				Mean,	7.187

Table XLI.

0.3 Wt. normal solution. Expt. 2 at 5°. Cell K_3. Resistance of membrane, 224,000 ohms. Manometer 9. Calc. gas pressure, 6.802 atms. Time of setting up cell, Feb. 13, 1909, 12.30 P.M. Initial pressure, 6.89 atms. Observed osmotic pressures:

		Atms.			Atms.
Feb. 15,	12.30 P.M.	7.219	Feb. 15,	11.00 P.M.	7.209
	5.00 P.M.	7.212	" 16,	12.00 M.	7.195
				Mean,	7.209
			Mean of experiments 1 and 2,		7.198
			Ratio of osmotic to gas pressure,		1.058

Table XLII.

0.3 Wt. normal solution. Expt. 1 at 10°. Cell F_3. Resistance of membrane, 150,000 ohms. Manometer M_1. Calc. gas pressure, 6.925 atms. Time of setting up cell, Jan. 26, 1911, 3.00 P.M. Initial pressure, 8.0 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 30	7.325	Feb. 1	7.347
31	7.319	2	7.337
		Mean,	7.332

Table XLIII.

0.3 Wt. normal solution. Expt. 2 at 10°. Cell E_3. Resistance of membrane, 220,000 ohms. Manometer 9. Calc. gas pressure, 6.925 atms. Time of setting up cell, Jan. 26, 1911, 3.00 P.M. Initial pressure, 7.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 30	7.324	Feb. 1	7.346
31	7.353	2	7.324
		Mean,	7.337
		Mean of experiments 1 and 2,	7.334
		Ratio of osmotic to gas pressure,	1.059

Table XLIV.

0.3 Wt. normal solution. Expt. 1 at 15°. Cell C_3. Resistance of membrane, 230,000 ohms. Manometer 6. Calc. gas pressure, 7.047 atms. Time of setting up cell, Jan. 16, 1911, 3.00 P.M. Initial pressure, 7.3 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 19	7.465	Jan. 21	7.466
20	7.463		
		Mean,	7.465

Table XLV.

0.3 Wt. normal solution. Expt. 2 at 15°. Cell T_3. Resistance of membrane, 110,000 ohms. Manometer M_1. Calc. gas pressure, 7.047 atms. Time of setting up cell, Feb. 2, 1911, 3.00 P.M. Initial pressure, 7.68 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 8	7.481	Feb. 10	7.498
9	7.498	11	7.465
		Mean,	7.486
		Mean of experiments 1 and 2,	7.476
		Ratio of osmotic to gas pressure,	1.061

Table XLVI.

0.3 Wt. normal solution. Expt. 1 at 20°. Cell I_3. Resistance of membrane, 214,000 ohms. Manometer 20. Calc. gas pressure, 7.17 atms. Time of setting up cell, Mar. 15, 1910, 11.00 A.M. Initial pressure, 7.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 16, 11.00 A.M.	7.570	Mar. 17, 11.00 P.M.	7.582
17, 1.00 P.M.	7.590	18, 9.00 P.M.	7.600
		Mean,	7.586

Table XLVII.

0.3 Wt. normal solution. Expt. 2 at 20°. Cell T_3. Resistance of membrane, 535,000 ohms. Manometer 9. Calc. gas pressure, 7.17 atms. Time of setting up cell, Mar. 15, 1910, 11.00 A.M. Initial pressure, 7.8 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 17, 10.00 A.M.	7.642	Mar. 18, 5.00 P.M.	7.618
5.00 P.M.	7.610	19, 9.00 P.M.	7.627
		Mean,	7.624

Table XLVIII.

0.3 Wt. normal solution. Expt. 3 at 20°. Cell M_3. Resistance of membrane, 270,000 ohms. Manometer 24. Calc. gas pressure, 7.17 atms. Time of setting up cell, Dec. 12, 1910, 2.00 P.M. Initial pressure, 7.2 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 16	7.629	Dec. 18	7.596
17	7.589	19	7.609
		Mean,	7.606
		Mean of experiments 1, 2 and 3,	7.605
		Ratio of osmotic to gas pressure,	1.060

Table XLIX.

0.3 Wt. normal solution. Expt. 1 at 25°. Cell K_3. Resistance of membrane, 280,000 ohms. Manometer 20. Calc. gas pressure, 7.292 atms. Time of setting up cell, Jan. 31, 1910, 12.00 M. Initial pressure, 7.15 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 1, 1.00 P.M.	7.728	Feb. 2, 5.00 P.M.	7.738
5.00 P.M.	7.734	10.00 P.M.	7.741
		Mean,	7.735

Table L.

0.3 Wt. normal solution. Expt. 2 at 25°. Cell R_2. Resistance of membrane, 92,000 ohms. Manometer 20. Calc. gas. pressure, 7.292 atms. Time of setting up cell, Mar. 2, 1910, 4.00 P.M. Initial pressure, 6.9 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 4, 1.00 P.M.	7.727	Mar. 5, 9.00 A.M.	7.703
5.00 P.M.	7.735	2.30 P.M.	7.712
		Mean,	7.719

Table LI.

0.3 Wt. normal solution. Expt. 3 at 25°. Cell C_3. Resistance of membrane, 200,000 ohms. Manometer 6. Calc. gas pressure, 7.292 atms. Time of setting up cell, Nov. 2, 1910, 1.00 P.M. Initial pressure, 7.3 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 3, 4.00 P.M.	7.725	Nov. 4, 11.00 P.M.	7.720
4, 9.00 A.M.	7.730	5, 9.00 A.M.	7.715
3.00 P.M.	7.720		
		Mean,	7.722

Table LII.

0.3 Wt. normal solution. Expt. 4 at 25°. Cell D_3. Resistance of membrane, 190,000 ohms. Manometer 9. Calc. gas pressure, 7.292 atms. Time of setting up cell, Nov. 2, 1910, 1.00 P.M. Initial pressure, 6.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 4	7.740	Nov. 6	7.732
5	7.732	7	7.742
		Mean,	7.738
		Mean of experiments 1, 2, 3 and 4,	7.729
		Ratio of osmotic to gas pressure,	1.060

Table LIII.

0.4 Wt. normal solution. Expt. 1 at 0°. Cell D_3. Resistance of membrane, 236,000 ohms. Manometer 13. Calc. gas pressure, 8.906 atms. Time of setting up cell, Feb. 2, 1909, 12.00 M. Initial pressure, 9.51 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 3, 12.00 M.	9.436	Feb. 4, 9.00 A.M.	9.462
5.00 P.M.	9.443	2.00 P.M.	9.458
		Mean,	9.450

Table LIV.

0.4 Wt. normal solution. Expt. 2 at 0°. Cell E_2. Resistance of membrane, 183,000 ohms. Manometer 6. Calc. gas pressure, 8.906 atms. Time of setting up cell, Mar. 27, 1909, 2.00 P.M. Initial pressure, 9.1 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 28, 11.00 A.M.	9.425	Mar. 29, 12.00 M.	9.440
29, 10.00 A.M.	9.434	3.00 P.M.	9.440
		Mean,	9.435
		Mean of experiments 1 and 2,	9.442
		Ratio of osmotic to gas pressure,	1.060

Table LV.

0.4 Wt. normal solution. Experiment 1 at 5°. Cell F_3. Resistance of membrane, 550,000 ohms. Manometer 13. Calc. gas pressure, 9.07 atms. Time of setting up cell, Jan. 30, 1909, 12.00 M. Initial pressure, 7.27 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 1, 9.30 A.M.	9.622	Feb. 1, 10.00 P.M.	9.623
1.00 P.M.	9.622	2, 9.00 A.M.	9.625
		Mean,	9.623

Table LVI.

0.4 Wt. normal solution. Expt. 2 at 5°. Cell E_2. Resistance of membrane, 550,000 ohms. Manometer 22. Calc. gas pressure, 9.07 atms. Time of setting up cell, Jan. 30, 1909, 12.00 M. Initial pressure, 8.79 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 31, 11.30 A.M.	9.596	Feb. 1, 1.00 P.M.	9.576
5.00 P.M.	9.586	4.00 P.M.	9.578
		Mean,	9.584

Table LVII.

0.4 Wt. normal solution. Expt. 3 at 5°. Cell K_3. Resistance of membrane, 550,000 ohms. Manometer 9. Calc. gas pressure, 9.07 atms. Time of setting up cell, Jan. 30, 1909, 12.00 M. Initial pressure, 9.28 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 30, 10.30 P.M.	9.644	Jan. 31, 5.30 P.M.	9.623
31, 11.30 A.M.	9.631	Feb. 1, 4.00 P.M.	9.571
		Mean,	9.617
		Mean of experiments 1, 2 and 3,	9.608
		Ratio of osmotic to gas pressure,	1.059

Table LVIII.

0.4 Wt. normal solution. Expt. 1 at 10°. Cell D_3. Resistance of membrane, 160,000 ohms. Manometer 21. Calc. gas pressure, 9.233 atms. Time of setting up cell, April 16, 1909, 12.30 P.M. Initial pressure, 8.76 atms. Observed osmotic pressures:

	Atms.		Atms.
April 17, 1.30 P.M.	9.786	April 18, 5.00 P.M.	9.795
9.30 P.M.	9.789	19, 9.00 A.M.	9.792
		Mean,	9.791

Table LIX.

0.4 Wt. normal solution. Expt. 2 at 10°. Cell O_3. Resistance of membrane, 150,000 ohms. Manometer 9. Calc. gas pressure, 9.233 atms. Time of setting up cell, April 19, 1909, 3.00 P.M. Initial pressure, 9.38 atms. Observed osmotic pressures:

	Atms.		Atms.
April 20, 3.00 P.M.	9.789	April 21, 1.00 P.M.	9.792
21, 11.00 A.M.	9.787	4.00 P.M.	9.793
		Mean,	9.790
		Mean of experiments 1 and 2,	9.790
		Ratio of osmotic to gas pressure,	1.060

Table LX.

0.4 Wt. normal solution. Expt. 1 at 15°. Cell M_3. Resistance of membrane, 150,000 ohms. Manometer 24. Calc. gas pressure, 9.396 atms. Time of setting up cell, Jan. 9, 1911, 1.00 P.M. Initial pressure, 9.92 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 12	9.920	Jan. 14	9.979
13	9.952	15	9.949
		Mean,	9.950

Table LXI.

0.4 Wt. normal solution. Expt. 2 at 15°. Cell N_3. Resistance of membrane, 160,000 ohms. Manometer 6. Calc. gas pressure, 9.396 atms. Time of setting up cell, Jan. 9, 1911, 1.00 P.M. Initial pressure, 9.86 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 11	9.937	Jan. 13	9.971
12	9.947	14	9.931
		Mean,	9.947
		Mean of experiments 1 and 2,	9.949
		Ratio of osmotic to gas pressure,	1.059

Table LXII.

0.4 Wt. normal solution. Expt. 1 at 20°. Cell G_3. Resistance of membrane, 110,000 ohms. Manometer 9. Calc. gas pressure, 9.56 atms. Time of setting up cell, Mar. 19, 1910, 1.00 P.M. Initial pressure, 10.2 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 20, 10.00 A.M.	10.138	Mar. 21, 9.00 P.M.	10.137
21, 4.00 P.M.	10.148	22, 1.00 P.M.	10.121

Mean, 10.136

Table LXIII.

0.4 Wt. normal solution. Expt. 2 at 20°. Cell I_3. Resistance of membrane, 285,000 ohms. Manometer 9. Calc. gas pressure, 9.56 atms. Time of setting up cell, Mar. 23, 1910, 3.00 P.M. Initial pressure, 10.4 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 26, 1.00 P.M.	10.161	Mar. 26, 11.00 P.M.	10.125
5.00 P.M.	10.135	28, 11.00 A.M.	10.129

Mean, 10.138

Mean of experiments 1 and 2, 10.137
Ratio of osmotic to gas pressure, 1.060

Table LXIV.

0.4 Wt. normal solution. Expt. 1 at 25°. Cell Q_3. Resistance of membrane, 540,000 ohms. Manometer 9. Calc. gas pressure, 9.723 atms. Time of setting up cell, Dec. 1, 1909, 4.00 P.M. Initial pressure, 10.129 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 2	10.305	Dec. 4	10.292
3	10.305		

Mean, 10.298

Table LXV.

0.4 Wt. normal solution. Expt. 2 at 25°. Cell T_3. Resistance of membrane, 357,000 ohms. Manometer 9. Calc. gas pressure, 9.723 atms. Time of setting up cell, Dec. 6, 1909, 5.00 P.M. Initial pressure, 10.910 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 7, 4.00 P.M.	10.298	Dec. 8, 5.00 P.M.	10.312
8, 11.00 A.M.	10.285	9, 4.00 P.M.	10.285

Mean, 10.295

Mean of experiments 1 and 2, 10.296
Ratio of osmotic to gas pressure, 1.059

Table LXVI.

0.5 Wt. normal solution. Expt. 1 at 0°. Cell M_3. Resistance of membrane, 160,000 ohms. Manometer 11. Calc. gas pressure, 11.133 atms. Time of setting up cell, April 9, 1909, 3.00 P.M. Initial pressure, 11.8 atms. Observed osmotic pressures:

	Atms.		Atms.
April 10, 9.00 A.M.	11.915	April 11, 11.00 A.M.	11.912
1.00 P.M.	11.912	12, 10.00 A.M.	11.890
		Mean,	11.907

Table LXVII.

0.5 Wt. normal solution. Expt. 2 at 0°. Cell E_3. Resistance of membrane, 140,000 ohms. Manometer 6. Calc. gas pressure, 11.133 atms. Time of setting up cell, April 9, 1909, 3.00 P.M. Initial pressure, 11.7 atms. Observed osmotic pressures:

	Atms.		Atms.
April 10, 1.00 P.M.	11.862	April 11, 5.00 P.M.	11.884
9.00 P.M.	11.869	12, 10.00 A.M.	11.912
		Mean,	11.882
		Mean of experiments 1 and 2,	11.895
		Ratio of osmotic to gas pressure,	1.068

Table LXVIII.

0.5 Wt. normal solution. Expt. 1 at 5°. Cell H_3. Resistance of membrane, 500,000 ohms. Manometer 9. Calc. gas pressure, 11.34 atms. Time of setting up cell, Jan. 21, 1909, 3.00 P.M. Initial pressure, 12.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 22, 4.30 A.M.	12.10	Jan. 22, 1.00 P.M.	12.10
9.00 A.M.	12.12	11.00 P.M.	12.08
		Mean,	12.10

Table LXIX.

0.5 Wt. normal solution. Expt. 2 at 5°. Cell E_3. Resistance of membrane, 550,000 ohms. Manometer 13. Calc. gas pressure, 11.34 atms. Time of setting up cell, Jan. 22, 1909, 3.30 P.M. Initial pressure, 10.74 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 23, 3.00 A.M.	12.09	Jan. 24, 5.00 P.M.	12.10
2.30 P.M.	12.10	25, 9.00 A.M.	12.09
		Mean,	12.10
		Mean of experiments 1 and 2,	12.10
		Ratio of osmotic to gas pressure,	1.067

Table LXX.

0.5 Wt. normal solution. Expt. 1 at 10°. Cell J_3. Resistance of membrane, 140,000 ohms. Manometer 24. Calc. gas pressure, 11.541 atms. Time of setting up cell, April 12, 1909, 11.00 A.M. Initial pressure, 12.91 atms. Observed osmotic pressures:

	Atms.		Atms.
April 13, 5.00 P.M.	12.289	April 14, 10.00 P.M.	12.298
14, 1.00 P.M.	12.298	15, 10.00 P.M.	12.298
		Mean,	12.296

Table LXXI.

0.5 Wt. normal solution. Expt. 2 at 10°. Cell F_3. Resistance of membrane, 181,000 ohms. Manometer 15. Calc. gas pressure, 11.541 atms. Time of setting up cell, April 12, 1909, 11.00 A.M. Initial pressure, 10.67 atms. Observed osmotic pressures:

	Atms.		Atms.
April 14, 9.00 A.M.	12.299	April 14, 10.00 P.M.	12.302
1.00 P.M.	12.297	15, 10.00 A.M.	12.292
		Mean,	12.298
		Mean of experiments 1 and 2,	12.297
		Ratio of osmotic to gas pressure,	1.066

Table LXXII.

0.5 Wt. normal solution. Expt. 1 at 15°. Cell F_5. Resistance of membrane, 160,000 ohms. Manometer 15. Calc. gas pressure, 11.745 atms. Time of setting up cell, Jan. 5, 1911, 3.00 P.M. Initial pressure, 12.563 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 7	12.563	Jan. 10	12.558
8	12.575	11	12.566
9	12.565		
		Mean,	12.565

Table LXXIII.

0.5 Wt. normal solution. Expt. 2 at 15°. Cell C_3. Resistance of membrane, 100,000 ohms. Manometer 24. Calc. gas pressure, 11.745 atms. Time of setting up cell, Jan. 24, 1911, 12.00 M. Initial pressure, 12.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 25	12.522	Feb. 24	12.537
26	12.535	25	12.531
27	12.544	26	12.536
28	12.534	27	12.533
29	12.536	28	12.532
30	12.552	Mar. 1	12.537
31	12.535	2	12.517
Feb. 1	12.536	3	12.517
2	12.538	4	12.524
3	12.524	5	12.529
4	12.541	6	12.533
5	12.537	7	12.523
6	12.529	8	12.528
7	12.532	9	12.530
8	12.531	10	12.546
9	12.539	11	12.534
10	12.533	12	12.544
11	12.527	13	12.533
12	12.530	14	12.532
13	12.527	15	12.552
14	12.536	16	12.533
15	12.525	17	12.532
16	12.526	18	12.535
17	12.536	19	12.533
18	12.534	20	12.540
19	12.524	21	12.536
20	12.537	22	12.545
21	12.524	23	12.539
22	12.535	24	12.527
23	12.535	25	12.522

Mean,	12.5326
Ratio of osmotic to gas pressure,	1.067
Mean of experiments 1 and 2,	12.5488
Ratio of osmotic to gas pressure,	1.068

Table LXXIV.

0.5 Wt. normal solution. Expt. 1 at 20°. Cell G_4. Resistance of membrane, 367,000 ohms. Manometer 15. Calc. gas pressure, 11.95 atms. Time of setting up cell, Jan. 20, 1910, 3.00 P.M. Initial pressure, 11.50 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 20, 9.30 P.M.	12.741	Jan. 21, 9.30 P.M.	12.738
21, 9.00 A.M.	12.754	22, 10.00 P.M.	12.735
		Mean,	12.742

Table LXXV.

0.5 Wt. normal solution. Expt. 2 at 20°. Cell R_3. Resistance of membrane, 162,000 ohms. Manometer 15. Calc. gas pressure, 11.95 atms. Time of setting up cell, Mar. 21, 1910, 2.00 P.M. Initial pressure, 12.55 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 22, 1.00 P.M.	12.753	Mar. 23, 9.00 A.M.	12.757
9.00 P.M.	12.763	24, 9.00 A.M.	12.742
		Mean,	12.754
		Mean of experiments 1 and 2,	12.748
		Ratio of osmotic to gas pressure,	1.067

Table LXXVI.

0.5 Wt. normal solution. Expt. 1 at 25°. Cell W_3. Resistance of membrane, 275,000 ohms. Manometer 9. Calc. gas pressure, 12.154 atms. Time of setting up cell, Oct. 19, 1909, 4.30 P.M. Initial pressure, 13.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Oct. 20, 9.00 A.M.	12.871	Oct. 21, 5.00 P.M.	12.920
20, 10.00 P.M.	12.948	22, 9.00 A.M.	12.918
21, 9.00 A.M.	12.937		
		Mean,	12.919

Table LXXVII.

0.5 Wt. normal solution. Expt. 2 at 25°. Cell T_3. Resistance of membrane, 285,000 ohms. Manometer 9. Calc. gas pressure, 12.154 atms. Time of setting up cell, Oct. 29, 1909, 4.30 P.M. Initial pressure, 12.51 atms. Observed osmotic pressures:

	Atms.		Atms.
Oct. 30, 9.00 A.M.	12.997	Nov. 1, 10.00 A.M.	12.915
31, 11.00 A.M.	12.991	1.00 P.M.	12.915
9.30 P.M.	12.918		
		Mean,	12.947

Table LXXVIII.

0.5 Wt. normal solution. Expt. 3 at 25°. Cell Q_3. Resistance of membrane, 220,000 ohms. Manometer 11. Calc. gas pressure, 12.154 atms. Time of setting up cell, Nov. 11, 1909, 5.00 P.M. Initial pressure, 12.74 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 12, 2.00 P.M.	12.912	Nov. 13, 1.00 P.M.	12.948
5.00 P.M.	12.912	9.30 P.M.	12.954
		Mean,	12.932

Table LXXIX.

0.5 Wt. normal solution. Expt. 4 at 25°. Cell T_3. Resistance of membrane, 370,000 ohms. Manometer 9. Calc. gas pressure, 12.154 atms. Time of setting up cell, Nov. 11, 1909, 5.00 P.M. Initial pressure, 11.32 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 12, 10.00 A.M.	12.963	Nov. 12, 11.00 P.M.	12.989
5.00 P.M.	13.001	13, 9.30 P.M.	12.935
		Mean,	12.972
		Mean of experiments 1, 2, 3 and 4,	12.943
		Ratio of osmotic to gas pressure,	1.065

Table LXXX.

0.6 Wt. normal solution. Expt. 1 at 0°. Cell E_3. Resistance of membrane, 151,000 ohms. Manometer 6. Calc. gas pressure, 13.359 atms. Time of setting up cell, Mar. 18, 1909, 3.00 P.M. Initial pressure, 14.02 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 19, 12.00 M.	14.364	Mar. 20, 2.00 P.M.	14.373
11.30 P.M.	14.363	5.00 P.M.	14.367
		Mean,	14.367

Table LXXXI.

0.6 Wt. normal solution. Expt. 2 at 0°. Cell Q_3. Resistance of membrane, 212,000 ohms. Manometer 11. Calc. gas pressure, 13.359 atms. Time of setting up cell, April 7, 1909, 3.00 P.M. Initial pressure, 14.3 atms. Observed osmotic pressures:

	Atms.		Atms.
April 8, 10.00 A.M.	14.400	April 9, 10.00 A.M.	14.399
10.00 P.M.	14.378	2.00 P.M.	14.404
		Mean,	14.395
		Mean of experiments 1 and 2,	14.381
		Ratio of osmotic to gas pressure,	1.0765

Table LXXXII.

0.6 Wt. normal solution. Expt. 1 at 5°. Cell J_3. Resistance of membrane, 360,000 ohms. Manometer 11. Calc. gas pressure, 13.604 atms. Time of setting up cell, Feb. 1, 1909, 4.00 P.M. Initial pressure, 10.28 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 2, 9.00 A.M.	14.604	Feb. 3, 9.00 A.M.	14.602
1.00 P.M.	14.617	12.30 P.M.	14.591
		Mean,	14.604

Table LXXXIII.

0.6 Wt. normal solution. Expt. 2 at 5°. Cell L_3. Resistance of membrane, 370,000 ohms. Manometer 20. Calc. gas pressure, 13.604 atms. Time of setting up cell, Feb. 1, 1909, 4.00 P.M. Initial pressure, 13.59 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 2, 9.00 A.M.	14.611	Feb. 2, 4.30 P.M.	14.601
1.00 P.M.	14.604	3, 12.30 P.M.	14.608
		Mean,	14.606
		Mean of experiments 1 and 2,	14.605
		Ratio of osmotic to gas pressure,	1.074

Table LXXXIV.

0.6 Wt. normal solution. Expt. 1 at 10°. Cell H_3. Resistance of membrane, 78,000 ohms. Manometer 15. Calc. gas pressure, 13.849 atms. Time of setting up cell, April 6, 1909, 12.30 P.M. Initial pressure, 13.58 atms. Observed osmotic pressures:

	Atms.		Atms.
April 7, 9.00 A.M.	14.838	April 8, 10.00 A.M.	14.847
1.00 P.M.	14.878	2.00 P.M.	14.861
		Mean,	14.856

Table LXXXV.

0.6 Wt. normal solution. Expt. 2 at 10°. Cell J_3. Resistance of membrane, 112,000 ohms. Manometer 20. Calc. gas pressure, 13.849 atms. Time of setting up cell, April 6, 1909, 12.30 P.M. Initial pressure, 14.63 atms. Observed osmotic pressures:

	Atms.		Atms.
April 7, 9.00 A.M.	14.862	April 8, 10.00 A.M.	14.851
9.00 P.M.	14.847	2.00 P.M.	14.856
		Mean,	14.854
		Mean of experiments 1 and 2,	14.855
		Ratio of osmotic to gas pressure,	1.073

Table LXXXVI.

0.6 Wt. normal solution. Expt. 1 at 15°. Cell A_5. Resistance of membrane, 160,000 ohms. Manometer 9. Calc. gas pressure, 14.094 atms. Time of setting up cell, April 18, 1910, 12.00 M. Initial pressure, 14.7 atms. Observed osmotic pressures:

	Atms.		Atms.
April 18	15.148	April 23	15.130
19	15.149	24	15.128
20	15.126	25	15.123
21	15.125	26	15.117
22	15.115	27	15.116
		Mean,	15.128

Table LXXXVII.

0.6 Wt. normal solution. Expt. 2 at 15°. Cell A_5. Resistance of membrane, 140,000 ohms. Manometer 20. Calc. gas pressure, 14.094 atms. Time of setting up cell, Jan. 21, 1911, 12.00 M. Initial pressure, 14.568 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 24, 9.00 A.M.	15.185	Jan. 26, 9.00 A.M.	15.140
25, 9.00 A.M.	15.156	5.00 P.M.	15.157
5.00 P.M.	15.168	27, 9.00 A.M.	15.152
		Mean,	15.160
		Mean of experiments 1 and 2,	15.144
		Ratio of osmotic to gas pressure,	1.073

Table LXXXVIII.

0.6 Wt. normal solution. Expt. 1 at 20°. Cell Z_2. Resistance of membrane, 550,000 ohms. Manometer 6. Calc. gas pressure, 14.339 atms. Time of setting up cell, Nov. 12, 1909, 4.00 P.M. Initial pressure, 15.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 13, 5.00 P.M.	15.408	Nov. 15, 12.00 M.	15.381
11.00 P.M.	15.405	5.00 P.M.	15.427
		Mean,	15.405

Table LXXXIX.

0.6 Wt. normal solution. Expt. 2 at 20°. Cell O_3. Resistance of membrane, 350,000 ohms. Manometer 5. Calc. gas pressure, 14.339 atms. Time of setting up cell, Nov. 19, 1909, 12.00 M. Initial pressure, 14.10 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 20, 10.00 P.M.	15.365	Nov. 21, 11.00 P.M.	15.387
21, 12.00 M.	15.388	22, 10.00 A.M.	15.339
		Mean,	15.370
		Mean of experiments 1 and 2,	15.388
		Ratio of osmotic to gas pressure,	1.073

Table XC.

0.6 Wt. normal solution. Expt. 1 at 25°. Cell M_3. Resistance of membrane, 275,000 ohms. Manometer 11. Calc. gas pressure, 14.585 atms. Time of setting up cell, Nov. 22, 1909, 2.00 P.M. Initial pressure, 15.54 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 23, 5.00 P.M.	15.623	Nov. 25, 5.00 P.M.	15.628
24, 9.00 A.M.	15.619	26, 9.00 P.M.	15.659
		Mean,	15.632

Table XCI.

0.6 Wt. normal solution. Expt. 2 at 25°. Cell K_3. Resistance of membrane, 525,000 ohms. Manometer 9. Calc. gas pressure, 14.585 atms. Time of setting up cell, Nov. 24, 1909, 12.30 P.M. Initial pressure, 13.45 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 27	15.602	Nov. 29	15.624
28	15.627	30	15.606
		Mean,	15.615

Table XCII.

0.6 Wt. normal solution. Expt. 3 at 25°. Cell R_3. Resistance of membrane, 96,000 ohms. Manometer 9. Calc. gas pressure, 14.585 atms. Time of setting up cell, Nov. 10, 1910, 4.00 P.M. Initial pressure, 14.6 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 13	15.632	Nov. 15	15.619
14	15.619	16	15.609
		Mean,	15.620

Table XCIII.

0.6 Wt. normal solution. Expt. 4 at 25°. Cell Q_2. Resistance of membrane, 110,000 ohms. Manometer 15. Calc. gas pressure, 14.585 atms. Time of setting up cell, Nov. 10, 1910, 4.00 P.M. Initial pressure, 14.85 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 16	15.654	Nov. 20	15.628
19	15.623	21	15.629
		Mean,	15.634
	Mean of experiments 1, 2, 3 and 4,		15.625
	Ratio of osmotic to gas pressure,		1.071

Table XCIV.

0.7 Wt. normal solution. Expt. 1 at 0°. Cell M_3. Resistance of membrane, 515,000 ohms. Manometer 5. Calc. gas pressure, 15.586 atms. Time of setting up cell, Feb. 23, 1909, 2.00 P.M. Initial pressure, 16.82 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 24, 12.00 M.	16.897	Feb. 25, 12.30 P.M.	16.878
9.30 P.M.	16.878	5.00 P.M.	16.871
		Mean,	16.881

Table XCV.

0.7 Wt. normal solution. Expt. 2 at 0°. Cell D_3. Resistance of membrane, 280,000 ohms. Manometer 6. Calc. gas pressure, 15.586 atms. Time of setting up cell, Mar. 24, 1909, 2.30 P.M. Initial pressure, 16.59 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 25, 9.30 A.M.	16.897	Mar. 26, 11.00 P.M.	16.892
5.00 P.M.	16.907	27, 2.00 P.M.	16.867
		Mean,	16.891
	Mean of experiments 1 and 2,		16.886
	Ratio of osmotic to gas pressure,		1.083

Table XCVI.

0.7 Wt. normal solution. Expt. 1 at 5°. Cell M_3. Resistance of membrane, 275,000 ohms. Manometer 9. Calc. gas pressure, 15.872 atms. Time of setting up cell, Feb. 2, 1909, 2.30 P.M. Initial pressure, 15.51 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 3, 12.30 P.M.	17.235	Feb. 4, 9.30 A.M.	17.215
10.00 P.M.	17.220	3.00 P.M.	17.199
		Mean,	17.217

Table XCVII.

0.7 Wt. normal solution. Expt. 2 at 5°. Cell J_3. Resistance of membrane, 270,000 ohms. Manometer 6. Calc. gas pressure, 15.872 atms. Time of setting up cell, Feb. 11, 1909, 12.30 P.M. Initial pressure, 16.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 12, 1.00 P.M.	17.196	Feb. 13, 10.30 A.M.	17.192
5.00 P.M.	17.185	3.00 P.M.	17.204
		Mean,	17.194
		Mean of experiments 1 and 2,	17.206
		Ratio of osmotic to gas pressure,	1.084

Table XCVIII.

0.7 Wt. normal solution. Expt. 1 at 10°. Cell F_3. Resistance of membrane, 278,000 ohms. Manometer 20. Calc. gas pressure, 16.157 atms. Time of setting up cell, Mar. 31, 1909, 12.30 P.M. Initial pressure, 16.73 atms. Observed osmotic pressures:

	Atms.		Atms.
April 1, 9.00 P.M.	17.478	April 2, 2.30 P.M.	17.498
2, 10.00 A.M.	17.486	10.00 P.M.	17.490
		Mean,	17.488

Table XCIX.

0.7 Wt. normal solution. Expt. 2 at 10°. Cell P_3. Resistance of membrane, 191,000 ohms. Manometer 9. Calc. gas pressure, 16.157 atms. Time of setting up cell, April 14, 1909, 12.30 P.M. Initial pressure, 17.25 atms. Observed osmotic pressures:

	Atms.		Atms.
April 14, 5.30 P.M.	17.530	April 15, 5.30 P.M.	17.519
15, 2.00 P.M.	17.512	10.00 P.M.	17.511
		Mean,	17.518
		Mean of experiments 1 and 2,	17.503
		Ratio of osmotic to gas pressure,	1.083

Table C.

0.7 Wt. normal solution. Expt. 1 at 15°. Cell Z_3. Resistance of membrane, 565,000 ohms. Manometer 9. Calc. gas pressure, 16.443 atms. Time of setting up cell, April 14, 1910, 12.30 P.M. Initial pressure, 16.5 atms. Observed osmotic pressures:

	Atms.		Atms.
April 16, 1.00 P.M.	17.820	April 17, 10.00 A.M.	17.820
8.00 P.M.	17.818	18, 10.00 A.M.	17.824
		Mean,	17.821

Table CI.

0.7 Wt. normal solution. Expt. 2 at 15°. Cell M_3. Resistance of membrane, 220,000 ohms. Manometer 24. Calc. gas pressure, 16.443 atms. Time of setting up cell, Jan. 20, 1911, 12.30 P.M. Initial pressure, 17.2 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 21, 7.00 P.M.	17.811	Jan. 23, 4.00 P.M.	17.797
22, 6.00 P.M.	17.827	24, 9.00 A.M.	17.797

Mean, 17.808
Mean of experiments 1 and 2, 17.815
Ratio of osmotic to gas pressure, 1.083

Table CII.

0.7 Wt. normal solution. Expt. 1 at 20°. Cell M_3. Resistance of membrane, 380,000 ohms. Manometer 6. Calc. gas pressure, 16.729 atms. Time of setting up cell, Dec. 2, 1909, 12.00 M. Initial pressure, 17.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 3, 5.00 P.M.	18.106	Dec. 4, 5.00 P.M.	18.142
4, 1.00 P.M.	18.183	5, 9.00 A.M.	18.110

Mean, 18.135

Table CIII.

0.7 Wt. normal solution. Expt. 2 at 20°. Cell D_3. Resistance of membrane, 380,000 ohms. Manometer 5. Calc. gas pressure, 16.729 atms. Time of setting up cell, Dec. 2, 1909, 12.00 M. Initial pressure, 17.10 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 3, 5.00 P.M.	18.138	Dec. 4, 5.00 P.M.	18.085
4, 10.00 A.M.	18.115	5, 8.00 P.M.	18.146

Mean, 18.121
Mean of experiments 1 and 2, 18.128
Ratio of osmotic to gas pressure, 1.084

Table CIV.

0.7 Wt. normal solution. Expt. 1 at 25°. Cell F_3. Resistance of membrane, 367,000 ohms. Manometer 9. Calc. gas pressure, 17.015 atms. Time of setting up cell, Dec. 17, 1909, 5.00 P.M. Initial pressure, 16.94 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 19	18.383	Dec. 21	18.445
20	18.471	22	18.445

Mean, 18.436

Table CV.

0.7 Wt. normal solution. Expt. 2 at 25°. Cell M_3. Resistance of membrane, 560,000 ohms. Manometer 9. Calc. gas pressure, 17.015 atms. Time of setting up cell, Dec. 21, 1909, 12.00 M. Initial pressure, 18.84 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 21	18.419	Dec. 24	18.446
22	18.450	25	18.413
23	18.452	26	18.423
		Mean,	18.434
	Mean of experiments 1 and 2,		18.435
	Ratio of osmotic to gas pressure,		1.083

Table CVI.

0.8 Wt. normal solution. Expt. 1 at 0°. Cell H_3. Resistance of membrane, 366,000 ohms. Manometer 5. Calc. gas pressure, 17.812 atms. Time of setting up cell, Feb. 19, 1909, 4.00 P.M. Initial pressure, 19.10 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 20, 12.00 M.	19.487	Feb. 21, 11.00 A.M.	19.496
11.00 P.M.	19.482	22, 9.00 A.M.	19.478
		Mean,	19.486

Table CVII.

0.8 Wt. normal solution. Expt. 2 at 0°. Cell D_3. Resistance of membrane, 550,000 ohms. Manometer 11. Calc. gas pressure, 17.812 atms. Time of setting up cell, Feb. 19, 1909, 4.00 P.M. Initial pressure, 19.01 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 20, 11.00 P.M.	19.448	Feb. 21, 6.00 P.M.	19.470
21, 11.00 A.M.	19.495	22, 9.00 A.M.	19.452
		Mean,	19.466
	Mean of experiments 1 and 2,		19.476
	Ratio of osmotic to gas pressure,		1.093

Table CVIII.

0.8 Wt. normal solution. Expt. 1 at 5°. Cell J_3. Resistance of membrane, 275,000 ohms. Manometer 20. Calc. gas pressure, 18.139 atms. Time of setting up cell, Feb. 4, 1909, 12.30 P.M. Initial pressure, 19.50 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 4, 10.00 P.M.	19.797	Feb. 5, 9.30 P.M.	19.802
5, 1.00 P.M.	19.788	6, 12.00 M.	19.793
		Mean,	19.795

Table CIX.

0.8 Wt. normal solution. Expt. 2 at 5°. Cell B_3. Resistance of membrane, 550,000 ohms. Manometer 9. Calc. gas pressure, 18.139 atms. Time of setting up cell, Feb. 9, 1909, 3.00 P.M. Initial pressure, 16.61 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 10, 1.00 P.M.	19.844	Feb. 11, 9.00 A.M.	19.846
10.30 P.M.	19.853	2.30 P.M.	19.853
		Mean,	19.849
		Mean of experiments 1 and 2,	19.822
		Ratio of osmotic to gas pressure,	1.093

Table CX.

0.8 Wt. normal solution. Expt. 1 at 10°. Cell F_3. Resistance of membrane, 220,000 ohms. Manometer 20. Calc. gas pressure, 18.466 ohms. Time of setting up cell, Mar. 17, 1909, 12.30 P.M. Initial pressure, 17.60 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 18, 1.00 P.M.	20.156	Mar. 19, 9.00 A.M.	20.152
9.00 P.M.	20.167	4.30 P.M.	20.133
		Mean,	20.152

Table CXI.

0.8 Wt. normal solution. Expt. 2 at 10°. Cell L_3. Resistance of membrane, 234,000 ohms. Manometer 20. Calc. gas pressure, 18.466 atms. Time of setting up cell, Mar. 26, 1909, 3.00 P.M. Initial pressure, 18.72 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 27, 5.00 P.M.	20.159	Mar. 28, 5.00 P.M.	20.195
28, 12.00 M.	20.162	29, 9.00 A.M.	20.159
		Mean,	20.169
		Mean of experiments 1 and 2,	20.161
		Ratio of osmotic to gas pressure,	1.092

Table CXII.

0.8 Wt. normal solution. Expt. 1 at 15°. Cell Z_3. Resistance of membrane, 555,000 ohms. Manometer 9. Calc. gas pressure, 18.792 atms. Time of setting up cell, April 4, 1910, 4.00 P.M. Initial pressure, 19.5 atms. Observed osmotic pressures:

	Atms.		Atms.
April 5, 1.00 P.M.	20.500	April 6, 9.00 P.M.	20.531
6, 9.00 A.M.	20.547	7, 12.00 M.	20.554
		Mean,	20.533

Table CXIII.

0.8 Wt. normal solution. Expt. 2 at 15°. Cell H_3. Resistance of membrane, 110,000 ohms. Manometer 22. Calc. gas pressure, 18.792 atms. Time of setting up cell, Jan. 18, 1911, 2.00 P.M. Initial pressure, 19.3 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 21	20.505	Jan. 23	20.539
22	20.531		
		Mean,	20.525

Table CXIV.

0.8 Wt. normal solution. Expt. 3 at 15°. Cell E_3. Resistance of membrane, 150,000 ohms. Manometer 9. Calc. gas pressure, 18.792 atms. Time of setting up cell, Jan. 18, 1911, 2.00 P.M. Initial pressure, 19.6 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 20	20.550	Jan. 22	2 .539
21	20.545	23	20.557
		Mean,	20.548
		Mean of experiments 1, 2 and 3,	20.535
		Ratio of osmotic to gas pressure,	1.093

Table CXV.

0.8 Wt. normal solution. Expt. 1 at 20°. Cell Z_3. Resistance of membrane, 570,000 ohms. Manometer 5. Calc. gas pressure, 19.119 atms. Time of setting up cell, Nov. 26, 1909, 12.00 M. Initial pressure, 19.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 27, 10.00 A.M.	20.912	Nov. 27, 11.00 P.M.	20.931
1.00 P.M.	20.972	28, 11.00 P.M.	20.896
		Mean,	20.928

Table CXVI.

0.8 Wt. normal solution. Expt. 2 at 20°. Cell Z_3. Resistance of membrane, 275,000 ohms. Manometer 24. Calc. gas pressure, 19.119 atms. Time of setting up cell, Feb. 11, 1911, 1.00 P.M. Initial pressure, 19.3 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 12, 1.00 P.M.	20.900	Feb. 13, 11.00 P.M.	20.892
13, 6.00 P.M.	20.879	14, 1.00 P.M.	20.861
		Mean,	20.883

Table CXVII.

0.8 Wt. normal solution. Expt. 3 at 20°. Cell E_3. Resistance of membrane, 140,000 ohms. Manometer 9. Calc. gas pressure, 19.119 atms. Time of setting up cell, Dec. 8, 1910, 12.00 M. Initial pressure, 19.41 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 10	20.907	Dec. 13	20.922
11	20.857	14	20.922
12	20.866	15	20.918
		Mean,	20.899

Table CXVIII.

0.8 Wt. normal solution. Expt. 4 at 20°. Cell D_3. Resistance of membrane, 250,000 ohms. Manometer 6. Calc. gas pressure, 19.119 atms. Time of setting up cell, Dec. 8, 1910, 12.00 M. Initial pressure, 20.5 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 11	20.921	Dec. 14	20.912
12	20.907	15	20.915
13	20.891		
		Mean,	20.909
		Mean of experiments 1, 2, 3 and 4,	20.905
		Ratio of osmotic to gas pressure,	1.093

Table CXIX.

0.8 Wt. normal solution. Expt. 1 at 25°. Cell F_3. Resistance of membrane, 140,000 ohms. Manometer 9. Calc. gas pressure, 19.446 atms. Time of setting up cell, Jan. 4, 1910, 3.00 P.M. Initial pressure, 19.06 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 5	21.281	Jan. 12	21.238
6	21.253	13	21.266
7	21.256	14	21.257
8	21.281	15	21.249
9	21.280	16	21.249
10	21.258	17	21.246
11	21.238	18	21.264
		Mean,	21.258

Table CXX.

0.8 Wt. normal solution. Expt. 2 at 25°. Cell W_3. Resistance of membrane, 367,000 ohms. Manometer 11. Calc. gas pressure, 19.446 atms. Time of setting up cell, Jan. 6, 1910, 2.00 P.M. Initial pressure, 20.77 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 8, 12.00 M.	21.252	Jan. 10, 11.00 P.M.	21.257
10, 1.00 P.M.	21.225	11, 11.00 A.M.	21.267
		Mean,	21.250
		Mean of experiments 1 and 2,	21.254
		Ratio of osmotic to gas pressure,	1.093

Table CXXI.

0.9 Wt. normal solution. Expt. 1 at 0°. Cell F_3. Resistance of membrane, 550,000 ohms. Manometer 11. Calc. gas pressure, 20.04 atms. Time of setting up cell, Feb. 17, 1909, 3.00 P.M. Initial pressure, 21.45 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 18, 8.30 A.M.	22.163	Feb. 19, 9.00 A.M.	22.130
5.00 P.M.	22.162	12.00 M.	22.140
		Mean,	22.149

Table CXXII.

0.9 Wt. normal solution. Expt. 2 at 0°. Cell D_3. Resistance of membrane, 160,000 ohms. Manometer 5. Calc. gas pressure, 20.04 atms. Time of setting up cell, Mar. 11, 1909, 2.30 P.M. Initial pressure, 21.78 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 12, 10.00 A.M.	22.075	Mar. 12, 10.00 P.M.	22.106
12.00 M.	22.079	13, 12.00 M.	22.086
		Mean,	22.087
		Mean of experiments 1 and 2,	22.118
		Ratio of osmotic to gas pressure,	1.104

Table CXXIII.

0.9 Wt. normal solution. Expt. 1 at 5°. Cell B_3. Resistance of membrane, 500,000 ohms. Manometer 9. Calc. gas pressure, 20.406 atms. Time of setting up cell, Jan. 18, 1909, 3.00 P.M. Initial pressure, 17.11 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 20, 10.00 A.M.	22.46	Jan. 22, 5.00 A.M.	22.53
21, 1.00 A.M.	22.53	9.00 A.M.	22.53
		Mean,	22.513

Table CXXIV.

0.9 Wt. normal solution. Expt. 2 at 5°. Cell Q_2. Resistance of membrane, 550,000 ohms. Manometer 20. Calc. gas pressure, 20.406 atms. Time of setting up cell, Feb. 19, 1909, 3.00 P.M. Initial pressure, 22.06 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 22, 9.00 A.M.	22.448	Feb. 22, 10.00 P.M.	22.445
3.00 P.M.	22.447	23, 9.00 A.M.	22.433
		Mean,	22.443
		Mean of experiments 1 and 2,	22.478
		Ratio of osmotic to gas pressure,	1.102

Table CXXV.

0.9 Wt. normal solution. Expt. 1 at 10°. Cell F_3. Resistance of membrane, 220,000 ohms. Manometer 9. Calc. gas pressure, 20.774 atms. Time of setting up cell, Mar. 24, 1909, 12.30 P.M. Initial pressure, 19.45 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 25, 5.00 P.M.	22.915	Mar. 26, 9.00 A.M.	22.915
9.00 P.M.	22.912	5.00 P.M.	22.902
		Mean,	22.911

Table CXXVI.

0.9 Wt. normal solution. Expt. 2 at 10°. Cell B_3. Resistance of membrane, 138,000 ohms. Manometer 21. Calc. gas pressure, 20.774 atms. Time of setting up cell, April 13, 1909, 12.30 P.M. Initial pressure, 19.02 atms. Observed osmotic pressures:

	Atms.		Atms.
April 14, 10.00 P.M.	22.860	April 15, 2.00 P.M.	22.857
15, 10.00 A.M.	22.866	9.00 P.M.	22.846
		Mean,	22.857
		Mean of experiments 1 and 2,	22.884
		Ratio of osmotic to gas pressure,	1.102

Table CXXVII.

0.9 Wt. normal solution. Expt. 1 at 15°. Cell T_3. Resistance of membrane, 185,000 ohms. Manometer 9. Calc. gas pressure, 21.141 atms. Time of setting up cell, April 28, 1910, 12.00 M. Initial pressure, 20.5 atms. Observed osmotic pressures:

	Atms.		Atms.
April 29, 9.00 A.M.	23.325	April 30, 5.00 P.M.	23.311
30, 9.00 A.M.	23.321	May 1, 11.00 A.M.	23.300
		Mean,	23.314

Table CXXVIII.

0.9 Wt. normal solution. Expt. 2 at 15°. Cell R_3. Resistance of membrane, 330,000 ohms. Manometer 20. Calc. gas pressure, 21.141 atms. Time of setting up cell, Jan. 16, 1911, 3.00 P.M. Initial pressure, 22.711 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 19, 11.00 A.M.	23.338	Jan. 20, 12.00 M.	23.282
5.00 P.M.	23.309	5.00 P.M.	23.254
		Mean,	23.296
		Mean of experiments 1 and 2,	23.305
		Ratio of osmotic to gas pressure,	1.102

Table CXXIX.

0.9 Wt. normal solution. Expt. 1 at 20°. Cell D_3. Resistance of membrane, 550,000 ohms. Manometer 15. Calc. gas pressure, 21.509 atms. Time of setting up cell, Mar. 17, 1909, 12.00 M. Initial pressure, 20.40 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 18	23.721	Mar. 20	23.727
19	23.707	21	23.701
		Mean,	23.715

Table CXXX.

0.9 Wt. normal solution. Expt. 2 at 20°. Cell A_3. Resistance of membrane, 250,000 ohms. Manometer 22. Calc. gas pressure, 21.509 atms. Time of setting up cell, Dec. 6, 1910, 12.00 M. Initial pressure, 20.65 atms. Observed osmotic pressures:

	Atms.		Atms.
Dec. 7	23.703	Dec. 10	23.733
8	23.702	11	23.731
9	23.702	12	23.734
		Mean,	23.718
		Mean of experiments 1 and 2,	23.717
		Ratio of osmotic to gas pressure,	1.103

Table CXXXI.

0.9 Wt. normal solution. Expt. 1 at 25°. Cell D_3. Resistance of membrane, 220,000 ohms. Manometer 9. Calc. gas pressure, 21.877 atms. Time of setting up cell, Jan. 20, 1910, 4.00 P.M. Initial pressure, 20.28 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 21	24.127	Jan. 24	24.102
22	24.148	25	24.125
23	24.120		
		Mean,	24.126

Table CXXXII.

0.9 Wt. normal solution. Expt. 2 at 25°. Cell B_3. Resistance of membrane, 550,000 ohms. Manometer 9. Calc. gas pressure, 21.877 atms. Time of setting up cell, Oct. 29, 1910, 12.00 M. Initial pressure, 22.2 atms. Observed osmotic pressures:

	Atms.		Atms.
Oct. 30, 11.00 A.M.	24.126	Nov. 1, 5.00 P.M.	24.133
31, 9.00 A.M.	24.114	2, 9.00 A.M.	24.124
Nov. 1, 9.00 A.M.	24.128		
		Mean,	24.125
		Mean of experiments 1 and 2,	24.126
		Ratio of osmotic to gas pressure,	1.102

Table CXXXIII.

1.0 Wt. normal solution. Expt. 1 at 0°. Cell D_3. Resistance of membrane, 180,000 ohms. Manometer 20. Calc. gas pressure, 22.265 atms. Time of setting up cell, Jan. 20, 1909, 4.00 P.M. Initial pressure, 24.35 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 21, 9.00 P.M.	24.883	Jan. 22, 5.00 P.M.	24.891
22, 12.00 M.	24.864	23, 9.00 A.M.	24.864
		Mean,	24.878

Table CXXXIV.

1.0 Wt. normal solution. Expt. 2 at 0°. Cell D_3. Resistance of membrane, 555,000 ohms. Manometer 11. Calc. gas pressure, 22.265 atms. Time of setting up cell, Feb. 13, 1909, 3.00 P.M. Initial pressure, 24.63 atms. Observed osmotic pressures:

	Atms.		Atms.
Feb. 14, 11.00 P.M.	24.760	Feb. 15, 1.00 P.M.	24.798
5.00 P.M.	24.763	16, 9.00 A.M.	24.776
		Mean,	24.774
		Mean of experiments 1 and 2,	24.825
		Ratio of osmotic to gas pressure,	1.115

Table CXXXV.

1.0 Wt. normal solution. Expt. 1 at 5°. Cell F_3. Resistance of membrane, 1,000,000 ohms. Manometer 21. Calc. gas pressure, 22.67 atms. Time of setting up cell, Jan. 13, 1909, 4.30 P.M. Initial pressure 18.56 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 14, 1.00 P.M.	25.31	Jan. 15, 9.00 A.M.	25.27
15, 12.30 A.M.	25.32	16, 12.30 P.M.	25.29
		Mean,	25.298

Table CXXXVI.

1.0 Wt. normal solution. Expt. 2 at 5°. Cell S. Resistance of membrane, 550,000 ohms. Manometer 20. Calc. gas pressure, 22.67 atms. Time of setting up cell, Jan. 16, 1909, 12.00 M. Initial pressure, 20.12 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 18, 5.00 A.M.	25.30	Jan. 19, 9.00 A.M.	25.32
9.30 P.M.	25.28	1.00 P.M.	25.30
		Mean,	25.30

Table CXXXVII.

1.0 Wt. normal solution. Expt. 3 at 5°. Cell K_3. Resistance of membrane, 1,100,000 ohms. Manometer 9. Calc. gas pressure, 22.67 atms. Time of setting up cell, Jan. 16, 1909, 12.30 P.M. Initial pressure, 21.83 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 16, 9.00 P.M.	25.32	Jan. 17, 11.00 A.M.	25.31
17, 7.30 A.M.	25.31	9.00 P.M.	25.26
		Mean,	25.30

Table CXXXVIII.

1.0 Wt. normal solution. Expt. 4 at 5°. Cell J_3. Resistance of membrane, 1,100,000 ohms. Manometer 21. Calc. gas pressure, 22.67 atms. Time of setting up cell, Jan. 16, 1909, 12.30 P.M. Initial pressure, 20.15 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 16, 9.00 P.M.	25.23	Jan. 18, 5.00 A.M.	25.25
17, 9.00 A.M.	25.25	10.00 P.M.	25.23
		Mean,	25.24

Table CXXXIX.

1.0 Wt. normal solution. Expt. 5 at 5°. Cell G_3. Resistance of membrane, 550,000 ohms. Manometer 22. Calc. gas pressure, 22.67 atms. Time of setting up cell, Jan. 19, 1909, 4.00 P.M. Initial pressure, 20.91 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 20, 10.00 A.M.	25.26	Jan. 21, 9.00 A.M.	25.24
21, 5.00 A.M.	25.25	1.00 P.M.	25.28
		Mean,	25.258
		Mean of experiments 1, 2, 3, 4 and 5,	25.283
		Ratio of osmotic to gas pressure,	1.115

Table CXL.

1.0 Wt. normal solution. Expt. 1 at 10°. Cell F_1. Resistance of membrane, 550,000 ohms. Manometer 6. Calc. gas pressure, 20.082 atms. Time of setting up cell, Mar. 3, 1909, 12.30 P.M. Initial pressure, 23.83 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 5, 9.30 A.M.	25.682	Mar. 6, 9.30 A.M.	25.692
1.00 P.M.	25.746	1.00 P.M.	25.695
		Mean,	25.704

Table CXLI.

1.0 Wt. normal solution. Expt. 2 at 10°. Cell B_3. Resistance of membrane, 220,000 ohms. Manometer 20. Calc. gas pressure, 23.082 atms. Time of setting up cell, Mar. 3, 1909, 12.30 P.M. Initial pressure, 22.46 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 5, 9.30 A.M.	25.704	Mar. 5, 10.00 P.M.	25.684
5.00 P.M.	25.671	6, 1.00 P.M.	25.670
		Mean,	25.682
		Mean of experiments 1 and 2,	25.693
		Ratio of osmotic to gas pressure,	1.113

Table CXLII.

1.0 Wt. normal solution. Exps. 1 at 15°. Cell G_3. Resistance of membrane, 370,000 ohms. Manometer 9. Calc. gas pressure, 23.49 atms. Time of setting up cell, April 11, 1910, 1.00 P.M. Initial pressure, 26.05 atms. Observed osmotic pressures:

	Atms.		Atms.
April 12, 12.00 M.	26.212	April 13, 4.00 P.M.	26.194
9.00 P.M.	26.211	14, 12.00 M.	26.207
		Mean,	26.206

Table CXLIII.

1.0 Wt. normal solution. Expt. 2 at 15°. Cell D_3. Resistance of membrane, 355,000 ohms. Manometer 15. Calc. gas pressure, 23.49 atms. Time of setting up cell, April 11, 1910, 1.00 P.M. Initial pressure, 26.00 atms. Observed osmotic pressures:

	Atms.		Atms.
April 13, 4.00 P.M.	26.182	April 15, 9.00 A.M.	26.131
14, 9.00 A.M.	26.180	3.00 P.M.	26.192
		Mean,	26.171
		Mean of experiments 1 and 2,	26.189
		Ratio of osmotic to gas pressure,	1.115

Table CXLIV.

1.0 Wt. normal solution. Expt. 1 at 20°. Cell P. Resistance of membrane, 370,000 ohms. Manometer 21. Calc. gas pressure, 23.899 atms. Time of setting up cell, Mar. 3, 1910, 4.00 P.M. Initial pressure, 23.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Mar. 4	26.629	Mar. 6	26.663
5	26.654	7	26.645
		Mean,	26.648

Table CXLV.

1.0 Wt. normal solution. Expt. 2 at 20°. Cell H_3. Resistance of membrane, 200,000 ohms. Manometer 22. Calc. gas pressure, 23.899 atms. Time of setting up cell, Nov. 29, 1910, 4.00 P.M. Initial pressure, 25.19 atms. Observed osmotic pressures:

	Atms.		Atms.
Nov. 30	26.620	Dec. 2	26.644
Dec. 1	26.645	3	26.598
		Mean,	26.627
		Mean of experiments 1 and 2,	26.638
		Ratio of osmotic to gas pressure,	1.115

Table CXLVI.

1.0 Wt. normal solution. Expt. 1 at 25°. Cell E_3. Resistance of membrane, 550,000 ohms. Manometer 15. Calc. gas pressure, 24.308 atms. Time of setting up cell, Jan. 26, 1910, 12.00 M. Initial pressure, 26.95 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 27	27.113	Jan. 30	26.971
28	27.081	31	26.976
29	27.000		
		Mean,	27.030

Table CXLVII.

1.0 Wt. normal solution. Expt. 2 at 25°. Cell W_3. Resistance of membrane, 366,000 ohms. Manometer 9. Calc. gas pressure, 24.308 atms. Time of setting up cell, Jan. 26, 1910, 12.00 M. Initial pressure, 26.00 atms. Observed osmotic pressures:

	Atms.		Atms.
Jan. 28	27.024	Jan. 30	27.101
29	27.106	31	27.074
		Mean,	27.0763
		Mean of experiments 1 and 2,	27.053
		Ratio of osmotic to gas pressure,	1.113

Table CXLVIII.

	Wt. normal conc. o.1.			o.2.			o.3.			o.4.			o.5.		
	O.P.	M.O.P.	Ratio.	O. P.	M.O.P.	Ratio.	O.P.	M.O.P.	Ratio.	O.P.	M.O.P.	Ratio.	O.P.	M.O.P.	Ratio.
0°				4.719											
0°	2.460			4.717			7.078								
0°	2.464			4.730			7.107			9.450			11.907		
0°	2.463	2.462	(1.106)	4.726	4.722	1.061	7.071	7.085	1.061	9.435	9.442	1.060	11.882	11.895	1.068
5°	2.452									9.623					
5°	2.451			4.812			7.187			9.584			12.100		
5°	2.453	2.452	1.082	4.825	4.818	1.063	7.209	7.198	1.058	9.617	9.608	1.059	12.100	12.100	1.067
10°	2.494														
10°	2.496														
10°	2.502			4.890			7.332			9.791			12.296		
10°	2.498	2.498	1.082	4.896	4.893	1.060	7.337	7.334	1.059	9.790	9.790	1.060	12.298	12.297	1.066
15°	2.547														
15°	2.535														
15°	2.541			4.981			7.465			9.950			12.565		
15°	2.538	2.541	1.082	4.988	4.985	1.061	7.486	7.476	1.061	9.947	9.948	1 059	12.533	12.549	1.068
20°				5.058											
20°				5.056											
20°				5.066			7.586								
20°	2.589			5.065			7.624			10.136			12.742		
20°	2.590	2.590	1.084	5.074	5.064	1.062	7.606	7.605	1.060	10.138	10.137	1.060	12.754	12.748	1.067
25°							7.735						12.932		
25°				5.154			7.719						12.972		
25°	2.635			5.139			7.722			10.298			12.919		
25°	2.632	2.634	1.084	5.150	5.148	1.059	7.738	7.729	1.060	10.295	10.296	1.059	12.947	12.943	1.065

Table CXLVIII (continued).

	Wt. normal conc. 0.6.			0.7.			0.8.			0.9.			1.0.		
	O.P.	M.O.P.	Ratio.	O.P.	M.O.P.	Ratio.	O.P.	M.O.P.	Ratio.	O.P.	M.O.P.	Ratio.	O.P.	M.O.P.	Ratio.
0°	14.367			16.881			19.486			22.149			24.876		
0°	14.395	14.381	1.076	16.891	16.886	1.083	19.466	19.476	1.093	22.087	22.118	1.104	24.774	24.825	1.115
5°													25.298		
5°													25.300		
5°													25.300		
5°	14.604			17.217			19.795			22.443			25.240		
5°	14.606	14.605	1.074	17.194	17.206	1.084	19.849	19.822	1.093	22.513	22.478	1.102	25.258	25.283	1.115
10°	14.856			17.488			20.152			22.911			25.704		
10°	14.854	14.855	1.073	17.518	17.503	1.083	20.169	20.161	1.092	22.857	22.884	1.102	25.682	25.693	1.113
15°							20.533								
15°	15.128			17.821			20.525			23.314			26.206		
15°	15.160	15.144	1.073	17.808	17.815	1.083	20.548	20.535	1.093	23.296	23.305	1.102	26.171	26.189	1.115
20°							20.928								
20°							20.883								
20°	15.405			18.135			20.899			23.715			26.648		
20°	15.370	15.388	1.073	18.121	18.128	1.084	20.909	20.905	1.093	23.718	23.717	1.103	26.627	26.638	1.115
25°	15.632														
25°	15.615														
25°	15.620			18.436			21.250			24.126			27.030		
25°	15.634	15.625	1.071	18.434	18.435	1.083	21.258	21.254	1.093	24.125	24.126	1.102	27.076	27.053	1.113

Table CXLIX.

Weight-normal concentration.

Temp.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	Mean osmotic pressure in atmospheres.									
0°	(2.462)	4.722	7.085	9.442	11.895	14.381	16.886	19.476	22.118	24.825
5°	2.452	4.818	7.198	9.608	12.100	14.605	17.206	19.822	22.478	25.283
10°	2.498	4.893	7.334	9.790	12.297	14.855	17.503	20.161	22.884	25.693
15°	2.541	4.985	7.476	9.949	12.549	15.144	17.815	20.535	23.305	26.189
20°	2.590	5.064	7.605	10.137	12.748	15.388	18.128	20.905	23.717	26.638
25°	2.634	5.148	7.729	10.296	12.943	15.624	18.434	21.254	24.126	27.053

Table CL.

Weight-normal concentration.

Temp.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	Ratio of osmotic to gas pressure.									
0°	(1.106)	1.061	1.061	1.060	1.0685	1.0765	1.083	1.093	1.104	1.115
5°	1.082	1.063	1.058	1.059	1.067	1.074	1.084	1.093	1.102	1.115
10°	1.082	1.060	1.059	1.060	1.066	1.073	1.083	1.092	1.102	1.113
15°	1.082	1.061	1.061	1.059	1.068	1.073	1.083	1.093	1.102	1.115
20°	1.084	1.062	1.060	1.060	1.067	1.073	1.084	1.093	1.103	1.115
25°	1.084	1.059	1.060	1.059	1.065	1.071	1.083	1.093	1.102	1.113
Mean.	1.083	1.061	1.060	1.060	0.067	1.074	1.083	1.093	1.103	1.114

The test of the law of Gay-Lussac as applied to osmotic pressure, within the range covered by this investigation, is the *constancy of the ratios* of osmotic to gas pressure in the several vertical columns of Table CL. It will be noted that this ratio *is constant*, within the necessary experimental errors, for each concentration, except in the case of the 0.1 weight-normal solution at 0°, which appears to constitute an exception to the rule otherwise applicable throughout. The ratio of osmotic to gas pressure in the 0.1 weight-normal solution at 0° is 1.106, instead of 1.082 to 1.084, as it was found to be at 5°, 10°, 15°, 20° and 25°, and the osmotic pressure is higher at 0° than at 5°. It is to be remembered in this connection as possibly explaining the anomaly that at 0° the 0.1 normal solution is within less than 0°.2 of its freezing temperature. It will be necessary, however, to ascertain whether the more concentrated solutions exhibit the same peculiarity at temperatures very near their freezing points before any satisfactory discussion of the matter can be undertaken. It will be observed, on referring to Table

CXLVIII, that more than the usual number of determinations of osmotic pressure were made with the 0.1 normal solution at 0°, 5,° 10° and 15,° and also with the 0.2 normal solution at 0°. This was done with a view to ascertaining with greater certainty whether the anomaly in question really exists. In order that the 0.1 normal solution should conform at 0° with what was found to be true in the case of all the other concentrations, its osmotic pressure must be about $2.227 \times 1.083 = 2.413$ atmospheres, instead of 2.462 atmospheres. The difference, 0.049 atmosphere, can hardly be ascribed to experimental errors in the case of a solution so dilute that unavoidable errors of meniscus and capillary depression are of little weight. Neither can it be ascribed to *thermometer effects,* since these were absent in the work at 0°.

If we except the 0.1 weight-normal solution at 0°, there is no longer any doubt in our minds that the osmotic pressures of all solutions containing from 0.1 to 1.0 gram-molecular weight of cane sugar in 1000 grams of water obey the law of Gay-Lussac between 0° and 25°. Nevertheless, we shall show in our next paper that the ratios of osmotic to gas pressure, which are so constant for each concentration between 0° and 25°, begin to decline at some temperature between 25° and 30°, and that the rate of decrease at higher temperatures is such as to lead one to suspect that the ratios will become unity for all concentrations at temperatures below the boiling point of the solvent. Such conduct on the part of cane sugar solutions can, of course, be ascribed with great plausibility to hydrates which are stable between 0° and 25°, but which gradually dissociate at higher temperatures However, discussion along this, or any other similar line, appears to us unprofitable until much more has been learned about the osmotic pressures of aqueous solutions of other substances than cane sugar.

JOHNS HOPKINS UNIVERSITY,
March 31, 1911.

ON THE ADDITION OF HYDROCYANIC ACID TO UNSATURATED COMPOUNDS.

[PRELIMINARY NOTE.]

By Philip H. Cobb.

In the course of an investigation of phenylmaleic and -fumaric acids which is in progress in this laboratory, it was discovered that when phenylpropiolic ester is treated with potassium cyanide by the method of Bredt and Kallen,[1] potassium carbonate and the nitrile of phenylsuccinic acid result. The mixture of the ester, dissolved in alcohol, and of an aqueous solution of two equivalents of potassium cyanide is boiled for some hours on the water bath. After filtering off the potassium carbonate the nitrile is obtained by the evaporation of the alcohol. It melts at 68°–69° when crystallized from water or diluted alcohol. It dissolves readily in cold chloroform, acetone, and strong alcohol, difficultly in cold, readily in hot carbon tetrachloride; it is practically insoluble in cold water, readily in hot. When warmed on the water bath with concentrated aqueous potassium hydroxide, ammonia is evolved. After the evolution has ceased the liquid is filtered from a little impurity and acidified. The precipitate crystallized from water melts at 165°–166° and is identical with phenylsuccinic acid prepared by another method. The melting point of a mixture of the two is the same.

A determination of the nitrogen in the compound gave the following values:

0.2020 gram substance gave 31 cc. nitrogen (absolute) measured over water; barometer, 772 mm.; thermometer, 19°.

	Calculated for $C_{10}H_8N_2$.	Found.
N	17.91	17.92

The reaction takes place as follows:

$$C_6H_5C{:}C.COOC_2H_5 + 2KCN + 2H_2O = C_6H_5.CHCN.CH_2.CN + K_2CO_3 + C_2H_5OH.$$

It is proposed to extend this research at once to other un-

[1] Ann. Chem. (Liebig), **294**, 338.

saturated acids and to certain unsaturated hydrocarbons as well.

TUFTS COLLEGE, MASS.,
Apr. 10, 1911.

A FURTHER INVESTIGATION OF CERTAIN DERIVATIVES OF *o*-SULPHOBENZOIC ACID.

BY PHILIP H. COBB AND GEORGE P. FULLER.

Remsen and Saunders[1] obtained the lactone $C_6H_4\begin{cases}C(C_6H_5)_2\\ >O\\ SO_2\end{cases}$ once, through the action of benzene and aluminium chloride on a mixture of the chlorides of *o*-sulphobenzoic acid. They were unable to obtain these results again. Fritzsch[2] and List and Stein[3] also made it by the same method. One of us[4] repeated the above experiment but failed to get the lactone. It was obtained,[5] however, by the action of phenylmagnesium bromide on the anhydride of *o*-sulphobenzoic acid.[6] The substance thus prepared melted at 162°–163°, and agreed in its chemical properties with that obtained by the above investigators.

In his article on the action of organo-metallic compounds on alkylated saccharins, F. Sachs[7] subjected several products thus prepared to the action of fuming hydrochloric acid in sealed tubes, and also to the action of concentrated sulphuric acid. In the case of the products containing only alkyl groups in the side chains, the treatment yielded sultams with sul-

[1] THIS JOURNAL, **17**, 347.

[2] Ber. d. chem. Ges., **29**, 2288.

[3] *Ibid.*, **31**, 1664.

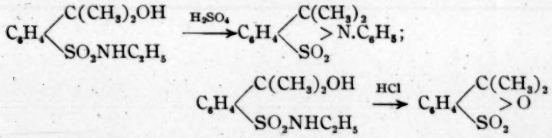
[4] Cobb: THIS JOURNAL, **35**, 498.

[5] *Ibid.*, p. 507.

[6] This substance was also prepared by the action of phenylmagnesium bromide on the low-melting chloride of *o*-sulphobenzoic acid. Analysis: 0.1984 gram substance gave 0.0802 gram H_2O and 0.5098 gram CO_2. Calculated for $C_{19}H_{14}O_3S$: H 4.34, C 70.76; found: H 4.53, C 70.08. The identity of the two substances was also established by taking a melting point of the mixture. It remained 163°. This reaction is analogous to the action of zinc ethyl on succinyl chloride, which gives γ-diethylhydroxybutyrolactone. Neither of these reactions can be considered as conclusive evidence for the structure of the corresponding chloride, as it is impossible to say that both of the chlorine atoms are substituted by direct replacement. The high-melting chloride of *o*-sulphobenzoic acid gives triphenylcarbinol-*o*-phenylsulphone with phenylmagnesium bromide (see THIS JOURNAL, **35**, 504).

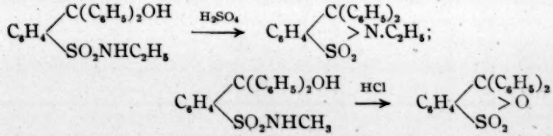
[7] Ber. d. chem. Ges., **37**, 3252.

phuric acid, and sultones with hydrochloric acid, as follows:

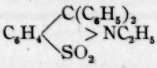


These products were well identified and undoubtedly possess the structure assigned to them.

Sachs also tried the action of hydrochloric and sulphuric acids on *N*-alkyl triphenylcarbinol-*o*-sulphonamides, with results represented as follows:



The conduct of these substances is apparently the same as that of the corresponding substances mentioned above, having alkyl groups in the place of phenyl. The analytical results for the sultam



are given, but not those for the substance obtained by the action of hydrochloric acid. Its melting point is 210°. The structure assigned to it, as well as its composition, is apparently based upon analogy to that of the compounds obtained in the corresponding reaction of those substances containing alkyl groups in the place of phenyl. Sachs remarks that the lactone obtained by Fritzsch (melting at 163°) was probably not pure.

If the substance obtained by Sachs were really the lactone, it follows that the compound previously described as the lactone was another substance, or else, as Sachs suggests, not entirely pure. The considerable difference in the melting point,

however, did not seem to warrant this assumption. To settle the point the work of Sachs, as far as it relates to this substance, was repeated.

Following his directions,[1] 20 grams of methylsaccharin were treated with 52 grams of phenylmagnesium bromide. The reaction product was crystallized from absolute alcohol and melted at 194°, thus agreeing with the melting point of the Sachs compound.

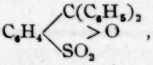
Three grams of this substance were heated with 80 cc. of fuming hydrochloric acid in a sealed tube for 15 hours at 150°. The reaction mixture was neutralized with sodium carbonate, filtered, and the solid remaining crystallized repeatedly from absolute alcohol. The melting point was 211°–212° (uncorr.), somewhat higher than that given by Sachs (210°). The presence of nitrogen was suspected, tested for, and proved.

Analysis:

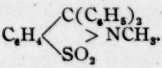
0.3799 gram substance gave 0.016756 gram nitrogen (absolute).

	Calculated for $C_{20}H_{17}O_3NS$.	Found.
N	4.18	4.41

It appears that the Sachs compound, to which he gave the formula of the sultone,



is not this substance, but instead is the nitrogen compound, the sultam,



To test the action of sulphuric acid on triphenylcarbinol-*o*-sulphonic methylamide, 2 grams of that substance were allowed to stand with concentrated sulphuric acid for 12 hours at about 50°. The mixture was colored deep red. It was poured on ice, and the resulting white solid was crystallized from absolute alcohol. It melted at 210°–211°. Mixtures

[1] *Loc. cit.*, p. 3267.

of the sulphuric and hydrochloric acid products melted at the same temperature. Furthermore, on analysis the substance gave the following results:

0.3792 gram substance gave 0.017147 gram nitrogen (absolute).

	Calculated for $C_{20}H_{17}O_3NS$.	Found.
N	4.18	4.52

Thus the identity of the substances formed by the two methods is proved. It seemed interesting to determine whether this action of hydrochloric acid on compounds of this type is general. Accordingly, phenylditolylcarbinol - *o* - sulphonic methylamide was prepared by the action of tolylmagnesium bromide (from *p*-bromtoluene) on methylsaccharin. The reaction product was boiled with alcohol to free it from an oily by-product, and was then crystallized from acetone. It melted at 243° (uncorr.). The compound is insoluble in ether and ligroin; slightly soluble in absolute alcohol, acetone, chloroform, benzene, toluene, and xylene.

Analysis:

0.3007 gram substance gave 0.0105546 gram nitrogen (absolute).

	Calculated for $C_{22}H_{23}O_3NS$.	Found.
N	3.68	3.51

From the method of its formation and the results of the analysis it is probable that the compound has the formula

$$C_6H_4\begin{cases} C(C_6H_4CH_3)_2OH \\ SO_2NHCH_3 \end{cases}.$$

The action of fuming hydrochloric acid was tried. The substance was heated with this reagent for 14 hours at 150°. The reaction mixture was then neutralized, filtered, and the product crystallized from alcohol. It melted at 243°. The reaction was also tried at 200° but no change took place. The action of concentrated sulphuric acid was tried as in the previous experiment, once at room temperature for 12 hours, again at 40° for 12 hours, and finally at 70° for the same

length of time. No change took place, however. The melting point after the treatment remained unchanged.

SUMMARY.

By identifying the Sachs compound as the sultam all doubt as to the identity of the lactone obtained by one of us[1] has been removed.

Sachs has shown that in at least two cases the action of hydrochloric and sulphuric acids is different. This difference exists where the compounds treated were obtained from alkyl saccharins by the action of alkyl magnesium halides. In their action on these compounds obtained from phenylmagnesium bromide and methylsaccharin, however, sulphuric and hydrochloric acids give the same product.

The attempt to obtain a reaction between hydrochloric or sulphuric acids and the ditolyl compound showed that this substance is too stable to be attacked by these reagents.

With sulphuric acid the reaction always takes place, if at all, with the elimination of water and the formation of the sultam. This is the normal action of this reagent, and it would remove water from compounds of this type if its affinity for water, aided by the conditions of the experiment, could overcome the resistance to its removal. It is seen above that the limit is reached in the ditolyl compound. For concentrated sulphuric acid to remove the elements of an amine would be impossible, as the first step in this process must be a hydrolysis, and the tendency to hydrolysis could never become great enough to take water out of concentrated sulphuric acid.

With concentrated hydrochloric acid, if the radicals of the side chain CR_2OH are aliphatic, the elements of an amine are removed and a sultone is formed. If they are phenyl groups, however, water is removed and a sultam is formed.

Concentrated hydrochloric acid is a substance which acts as a hydrolyzing agent in many cases, and which also possesses an affinity for water. Which of these properties it displays in a given case will depend upon the nature of the substance attacked, and the reaction taking place will be the

[1] Cobb: *Loc. cit.*

one which leaves the system in the better state of chemical neutralization. In the case of compounds of the type $C_6H_4\begin{cases}CR_2OH\\SO_2NHR'\end{cases}$, which differ among themselves only that in one case R represents an aliphatic radical and in the other phenyl, it is evident that the different action of hydrochloric acid is due to the different effect of the two kinds of radicals in this class of substances.

When the radicals are aliphatic the formation of the sultone is due to hydrolysis and the subsequent splitting out of water, thus:

$$C_6H_4\begin{cases}CR_2OH\\SO_2NHR'\end{cases} \xrightarrow[HCl]{H_2O} C_6H_4\begin{cases}CR_2OH\\SO_2OH\end{cases} \longrightarrow C_6H_4\begin{cases}CR_2\\>O\\SO_2\end{cases}$$

and where the radicals are phenyl a simple dehydration takes place, thus:

$$C_6H_4\begin{cases}C(C_6H_5)_2OH\\SO_2NHR'\end{cases} \longrightarrow C_6H_4\begin{cases}C(C_6H_5)_2\\>NR'.\\SO_2\end{cases}$$

The causes bringing about the first series of reactions are the affinity of hydrochloric acid for the amine and the increase in chemical neutralization due to the splitting out of water from the hydrolyzed product. The opposing force is due to the resistance of the original compound to hydrolysis. The sum of these opposite forces is positive and the result is a number of reactions whose effect is exothermic. Therefore, under the conditions of the experiment (high temperature and pressure), the progress of these reactions results in a better state of chemical neutralization. At ordinary temperatures the resistance to hydrolysis is so great that the reaction does not take place.

In the second case, where the radicals are phenyl groups, the reaction proceeds quite differently. In this case the loss of water has become a chemical act opposed by less resistance than was the case in the preceding class of compounds, and which is also more easily effected than the loss of an amine by hydrolysis. This is probably due to the effect of the phenyl

groups in facilitating dehydration, as is the case in the following acids: Phthalic acid loses water more easily than succinic, phenylsuccinic more easily than methylsuccinic, and phenylmaleic more easily than citraconic.

While the union of hydrochloric acid with the amine, if it were split out by hydrolysis, would produce a much more exothermic effect than its union with water, the difference is not great enough to overcome the difference in energy expenditure required to separate the two substances, water or the amine, from the original compound.[1] To effect the hydrolysis would require so great an expenditure of energy that the reaction would be endothermic relatively to the one that actually takes place. Hence in this case the reaction would result in a less complete neutralization of the system than the one that occurs.

TUFTS COLLEGE, MASS.,
April 10, 1911.

REVIEWS.

THE RELATIONS BETWEEN CHEMICAL CONSTITUTION AND SOME PHYSICAL PROPERTIES. By SAMUEL STILES, D.Sc., Fellow of University College, and Assistant Professor of Organic Chemistry at University College, London University. London, New York, Bombay, and Calcutta: Longmans, Green & Co. 1910. pp xiv + 583. Price, $4.

This is one of the text-books of Physical Chemistry edited by Sir William Ramsay, K.C.B., F.R.S.

In the preface the author says: "As indicated by the title, this volume does not exhaustively treat of the whole subject in question. For various reasons a few physical properties have been omitted from consideration, the more important being Crystalline Form, Optical Rotatory Power, Electric Conductivity, and Heat of Combustion. The relations between the first named of these properties and chemical constitution could not be fully understood without some general account of crystalline structure and the methods of measurement, so that a satisfactory treatment of this subject would occupy so much space as to require a separate volume. The relations between Constitution and Optical Rotatory

[1] It is not intended to imply that the energy liberated by the union of the reagent with water or the amine, after the removal of that substance has taken place, does the work of separating these substances. This energy is furnished by the reagents and the heat supply. But the energy liberated in the two cases is a fair measure of the relative affinities of water and the amine for that acid.

Power, Electric Conductivity, and Heat of Combustion have been thoroughly dealt with in the volumes of this series entitled 'Stereochemistry,' 'Electrochemistry,' and 'Thermochemistry.' Some other physical properties, for example, Solubility, Dielectric Constant, and Magnetic Susceptibility, have been omitted because the relations between them and constitution are not yet sufficiently elucidated for special treatment."

Under the head "Mechanical Properties" there are three chapters which deal respectively with Capillarity, Viscosity, and Volume Relations. Under "Thermal Properties" the subjects of Specific Heat, Fusibility, and Boiling Point are treated of. Under "Optical Properties" come Refractive and Dispersive Power, Absorption of Light, Fluorescence, and Magnetic Rotating Power. Finally Anomalous Electric Absorption is dealt with under the general heading "Electrical Property."

The book is clearly written and is based upon the original sources to which abundant references are given.

In the concluding chapter occurs this passage which is worth quoting: "This problem of the nature of valency is undoubtedly the most important of those awaiting solution from the chemist. The opinion of chemists seems divided as to whether the electronic theory can be accepted or not. Against its adoption it is urged that the electron is nothing but a figment of the physicist's imagination, and that chemists can derive no real benefit from it. But it may be pertinently asked whether the atom is not equally a figment of the chemist's imagination, and are we to reject this too? At present, however, the electronic theory seems to be the only means by which there is any prospect of attaining further knowledge of the nature of valency, and this circumstance alone should be sufficient recommendation for a thorough trial. At any rate, if we reject it we have nothing else to offer as an adequate substitute."

The book is warmly recommended to students of chemistry whether they be young or old. I. R.

INTRODUCTORY NOTES ON QUANTITATIVE CHEMICAL ANALYSIS. By CHARLES WILLIAM FOULK, Professor of Analytical Chemistry in the Ohio State University. Second edition. Revised and enlarged. Columbus, O. 1910. pp. ix + 250. Price, $2.50.

The keynote of this manual is practical helpfulness to the beginning analyst. The author's aim is that of all good teachers of the subject, namely, to train their students to thoughtful, self-critical work, and the distinctive feature of these "Notes" is the large amount of descriptive and ex-

planatory matter which is presented as bearing upon all analytical work, rather than upon any one procedure, or even to any group of methods. This material constitutes Part I, amounting to 129 pages, and is entitled "Principles of Chemistry and Manipulation in Quantitative Analysis." It is subdivided into introductory matter (glass-working, equipment, weighing and the balance), gravimetric analysis (sampling, precipitation, filtration, ignition, evaporation, management of work, note-books, and accuracy of analysis), and volumetric analysis (measurement of liquids, calibration, standard and normal solutions, titration and indicators).

"Practice Work in Quantitative Analysis" constitutes Part II, which comprises directions for the analysis of eleven substances and the preparation of some standard solutions. These directions are accompanied by explanatory notes bearing upon the particular determinations involved. With one exception, the materials analyzed are natural or manufactured products of commercial importance.

The attractiveness of this book lies in the candid, man-to-man fashion in which the author deals with his subject. This is particularly true of the sections on the "Accuracy of Chemical Analysis," in which the troublesome question of "check results" is admirably dealt with. A conscientious reader of Part I can hardly fail to gain an intelligent notion of the considerations which govern such matters as the choice of analytical methods and the amounts of materials to be taken for examination, to name only two of the important topics discussed. Whether a considerable proportion of a large class can be persuaded to read carefully, and assimilate, 129 pages of good advice is always a doubtful question, and will obviously depend largely on the pressure brought to bear upon the members of the class by the instructor. It may be questioned whether the treatment of certain topics (notably, the solubility-product principle) is adequate, and the suggestion (p. 57) that successive volumes of 800 to 900 cc. of water may be used to wash an aluminium hydroxide precipitate may be criticized, if subsequent determinations are to be made in the filtrate; but these are minor points in a mass of highly useful material, and the book is well worthy the attention of all thoughtful teachers.

H. P. TALBOT.

INTRODUCTION TO THE ANALYSIS OF DRUGS AND MEDICINES. An Elementary Handbook for the Beginner. By BURT E. NELSON, Chemist to the New York State Hospitals, The Department of Health, Board of Water Commissioners, etc. First edition. New York: John Wiley & Sons. 1910. pp. xii + 384. Price, $3.

In the preface the author states that the book is intended

to furnish methods by which the student or analyst who is not specialized in drug chemistry may obtain information which is often desired by Health Departments, the State and the general public. The headings of some of the chapters are as follows: "Ultimate Inorganic Analysis," "Ultimate Organic Analysis," "Determination of Molecular Weights," "Common Radicles and Chemical Formulae," "Systematic Microscopical Drug Analysis," "Phamacological Methods," etc. From this it will be seen that the author attempts to cover within this small work several very large fields of work which bear more or less on the problem of the drug analyst. For this reason the statements are frequently so brief that they would be practically meaningless to any one but an advanced student and they are not sufficiently detailed to be of much service to him.

The chapter on pharmacological methods should certainly have been omitted, as in the reviewer's opinion it cannot be of service to any one, and the author could have devoted these pages far more profitably to further amplify other phases of the work. The same statement also applies to pages 93 to 96, wherein the author gives directions for the recognition of hydroxyl, carboxyl, methoxyl, ethoxyl, carbonyl, amino, amido, nitrile, imino, diazo, hydrazide, nitro, nitroso peroxide and iodoso groups—all within four pages.

The book would be of far greater service if it were more detailed and were narrower in its scope. A. S. L.

A TEXT-BOOK OF BOTANY AND PHARMACOGNOSY. By HENRY KRAEMER, Ph.B., Ph.D., Professor of Botany and Pharmacognosy in the Philadelphia College of Pharmacy. Illustrated with over 300 plates comprising about 2000 figures. Fourth edition, revised and enlarged. Philadelphia and London: J. B. Lippincott Co. pp. viii + 888. Price, $5.00.

This new edition of Kraemer's Text-Book is divided about equally between the subjects indicated in the title.

The first chapter deals with the great groups of plants, and in it the author undertakes to present their characteristics, relationships, reproductive processes and economic uses; this is rather a large order for the space devoted to it, and results in a condensed form of presentation.

Chapters follow on the outer and inner morphology of the higher plants, one on the classification of angiosperms, and a short chapter on drug cultivation. This part of the book is well illustrated. The idea of centrospheres in higher plants seems to die hard, for it is here again repeated with Strasburger's early cut.

In the section devoted to Pharmacognosy, each drug is described briefly and its names, habitat, range and principal constituents given. Allied products and plants are also mentioned. It seems rather unfortunate, however, that the medicinal action of the drug is in most cases omitted.

The chapter on powdered drugs is furnished with an identification key in which the main classification is according to color. The key is carefully worked out and illustrated and should prove of value to druggists who use the microscope.

The chapter on the crystallographic study of a number of drugs is new in this edition. It is illustrated by a number of pictures of microscopic crystals.

The book is well printed and illustrated throughout and will be welcomed by food analysts and druggists as a book of reference.

R. H. DENNISTON.

KRAFTGAS. Seine Herstellung und Beurteilung. Von. PROF. DR. FERDINAND FISCHER, Professor an der Universität Göttingen. Mit 186 Figuren im Text. Leipzig: Verlag von Otto Spamer. 1911. s. viii + 236. Preis, geh., M. 12; geb., M. 13.50.

The book discusses thoroughly the methods of testing and investigating power gases, the raw materials for their production and the theoretical considerations involved in their manufacture.

German generators are the ones chiefly described, although one finds those of Messrs. Solvay and Taylor. The book is, from this standpoint, more valuable to the European than the American. Scant attention is paid to the extensive use of blast-furnace gas for power in this country. Particularly interesting and opportune are the chapters upon Brown Coal, Peat, Wood, and Blast-Furnace Gases.

It is to be regretted that so good a book is furnished with so insufficient an index; a list of author's or patentees' names would be very helpful.

A. H. GILL.

VAN NOSTRAND'S CHEMICAL ANNUAL 1909. A Handbook of Useful Data for Analytical, Manufacturing and Investigating Chemists. Second issue. Edited by JOHN C. OLSEN, A.M., Ph.D., Professor of Analytical Chemistry, Polytechnic Institute, Brooklyn. New York: D. Van Nostrand Co. 1909. pp. xii + 580. Price, $2.50.

In this second edition of Van Nostrand's Chemical Annual the tables of the properties of the elements and of inorganic and organic compounds have been thoroughly revised and the table of gravimetric factors and their logarithms has been recalculated on the basis of the 1909 International Atomic Weights. Tables on the physical constants of the alkaloids and of essential oils and various other additions have been

introduced. The reviewer has been using the book for some time and has found it uniformly accurate and up-to-date. The printing and binding are up to the Van Nostrand standard, the legibility procured by the large type and opaque paper more than compensating for the somewhat larger size of the book as compared with pocket reference manuals. The 108 pages, forming nearly one-fifth of the book, devoted to a list of the principal papers and books on chemical subjects published since the appearance of the first issue of the Annual, might, however, in the reviewer's opinion, be left out without much detracting from the value of the book, and the purchaser be given the benefit of the saving in the cost of production. C. A. R.

ANNUAIRE POUR L'AN 1911. Avec des Notes Scientifiques. Paris: Gauthier-Villars, Imprimeur-Libraire du Bureau des Longitudes. pp. vii + 761. Price, Fr. 1.50.

This little Annual (little in the size but not in the number and contents of its pages) is published by the Bureau des Longitudes. Every alternate year, tables of physical and chemical data are given, but 1911 happens to be an "off" year for these subjects and the present volume is devoted to astronomical, geographic and statistical data. Thus we find 73 pages given to the Gregorian, Julian, French Republican, Jewish, Turkish, Coptic and Chinese calendars, 20 to celestial phenomena during 1911, 184 to data on the solar system, 204 to geographical data, 8 to legal time in various parts of the world, 12 to French mortality tables, 88 to coins, weights and measures, 32 to interest tables, and 17 to meteorological data, chiefly for Paris. There are also appended reports on the 16th Meeting of the International Geodetic Association by H. Poincaré and on the Solar Eclipse of April 17th, 1912, by G. Bigourdon, an obituary of Bouquet de la Grye by H. Poincaré, and an address by the same author delivered at the funeral of Paul Gautier, December 9, 1909. C. A. R.

NITROCELLULOSE INDUSTRY. By EDWARD CHAUNCEY WORDEN, PH.C., M.A., F.C.S. Over 8000 Patent and Literature References to the Work of over 2900 Different Investigators. Two Volumes, 324 Illustrations. New York: D. Van Nostrand Co. 1911. pp. xxxiv + 1239. Price, $10.00.

This work is styled in its sub-title "a compendium of the history, chemistry, manufacture, commercial application and analysis of nitrates, acetates and xanthates of cellulose as applied to the peaceful arts, with a chapter on gun cotton, smokeless powder and explosive cellulose nitrates," but the

author has not been able to resist the temptation which presents itself to every student of chemical technology and which appeals most strongly to him who deals with an industry from the broadest scientific viewpoint, for he knows that his narration is not complete and that a true presentation of the development and existing conditions for any one industry cannot be made without a somewhat detailed account of the collateral and interdependent industries. Consequently the author deals not only with pyroxylin plastic substitutes and their various applications but he devotes much space to solvents and nonsolvents, fusel oil and the amyl alcohols, amyl acetates, natural, artificial and synthetic camphor and camphor substitutes, paint and varnish removers and turpentine substitutes, denatured alcohol, and other topics, giving the sources, methods of manufacture, properties and tests of most of these materials, and to this, for the information of manufacturers, adds a chapter on the transportation of explosives and inflammables, as regulated by the Bureau of the American Railway Association.

Considering the work as a whole, while it treats of most, if not all, of the applications of the cellulose nitrates, and of many of the industries based on these applications, with marked fulness of detail, yet the impression on reading is that the author focuses his attention on the proxylin plastic industries, which present in their treatment of the material, and applications of the products, a wide range of ingenuity, versatility, and usefulness and which are best exemplified in the composition of matter known under the copyrighted name of "celluloid." It may safely be said that this book gives the most detailed, precise and complete account of this industry thus far published. It is interesting, in view of popular opinion, to note that, in describing proxylin plastics, the author says: "When properly prepared, celluloid cannot be caused to explode by heat, friction, or percussion."

The text of this book is reinforced by most voluminous explanatory notes. Of the 1145 pages of text only 150 are free from notes and 31 of these are devoted to reprints of official documents. In some instances the explanatory, well digested notes cover nearly the whole page. While scientific authorities have been freely consulted and their results frankly presented without prejudice, the greatest stress, both in text and notes, is laid, as it should be for modern industries, upon patent literature. The descriptions of apparatus, methods, processes and products drawn from these literary sources is set forth with completeness, but a reader skilled in the art will observe that the author has exercised that discretion, when

describing commercial operations, which good taste and justice to manufacturers demands.

In order that the wealth of information here collected may be made available the author gives a list of American and English Patents on pyroxylin plastics covering 19 pages; an index to U. S. and foreign patents covering all the industries treated of; an index of "authors;" an index of subjects; and a table of contents, with an extended list of abbreviations used, which is prefixed to each volume. The indexes include the notes as well as the text.

With these manifest evidences of painstaking care and industry in the preparation of this work one hesitates to criticize, yet it must be said that the text is at times so rough and involved that one is in doubt as to the author's meaning, and that, despite the careful research made by the author, he has sought to cover so broad a field that he has perforce failed to cover it completely, while slips such as "native Franklinite (zinc carbonate) plentiful in New Jersey" are to be expected.

In spite of these minor defects the treatise is most valuable to manufacturer, investigator and student and it must without doubt achieve the position of "authority" in the major topics of which it treats.

CHARLES H. MUNROE.